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Frozen Concrete.

Last winter was so open and mild in most parts of the country that a large amount of concrete construction was carried on at a season when such work is generally undertaken with extreme reluctance. It is apparent that the good results obtained last winter are the excuse for carrying on concrete work now, although the reports of the Weather Bureau show that severe cold is generally prevalent and all the "signs" point to a long period characterized by low temperature. There are a number of works under construction where it is good business policy to run the risk of partial failure of the structure when finished rather than to abandon the possibility of their successful completion at an early date. If these structures are carried through in

the winter and are satisfactory after the spring thaws have done their worst to injure them, well and good; if the test of weather and loading shows that frost entered into the structures in such a way as to reduce their strength and make their reconstruction necessary, then the owners of the structures cannot complain, because no engineer fails to warn his clients that concrete construction in freezing weather, particularly if the concrete is in long, thin members or slabs, like those in buildings, is something of a gamble which cannot be deprived of all elements of chance even with the best of care and materials.

It is now pretty well recognized, however, that the effect of freezing on concrete made with Portland cement is much less serious than it is on natural cement concrete. Moreover, the effect of the frost does not appear to be serious unless freezing and thawing alternate in such a way that the water in the concrete mixture is frozen before it has been able to play its part in the chemical changes that take place in hardening. If fresh concrete is frozen and stays in that condition for some weeks or months, it will probably not be injured if it has plenty of time after thawing to harden before it is again subjected to cold. On the other hand, if fresh concrete is alternately frozen and thawed daily it will probably become pretty poor stuff, cracked on the outside and a mass of dry powder, sand and stone without cohesion inside. This is of so little importance in great masses of concrete employed only to obtain weight or as a backing for stone masonry that occasionally it leads to the belief that similar effects are unimportant in the fine concrete work used in buildings and sidewalks. This is, of course, a great mistake, for it is absolutely necessary in such construction to have a material of uniform strength throughout its mass. In order to obtain such a result in freezing weather it is necessary to keep the fresh work warm, and various methods of doing this have been followed. Where the concrete is in large masses, it is generally sufficient to roof them over and warm them with steam pipes, a proceeding that has also been adopted in finishing large concrete bridges. Where the structure is a building, however, the heating is more difficult on account of the large number of small pieces of concrete that have to be kept warm in spite of large window openings. On account of the importance of such provision in a winter like that to be expected this year, attention is called to the very satisfactory plan followed by Mr. E. L. Ransome in erecting some concrete buildings during a winter when the temperature averaged considerably below freezing most of the time. This plan was described in detail in The Engineering Record of March 4, 1905, and consisted in substance of closing all window openings with duck curtains, covering the floors as soon as poured with plank panels, raised about 6 in. above their top surface and then heating the story enclosed in this way with salamanders. Steam pipes were run into the story from a boiler employed also to warm the sand and stone and live steam was discharged directly from them into the enclosed space, thus moistening the air, which is very desirable, as well as warming it.

These precautions for warming the fresh concrete, coupled with facilities for warming the sand and stone, cost a good deal of money, and also retard progress on the work. In large cities, where radiation from innumerable buildings tends to keep the temperature of the air high during the winter, and the presence of buildings along both sides of all streets cuts down the strength of the winds, it is possible to neglect such precautions as those mentioned rather more than is advisable in the open country. Conditions may also arise where the cost of taking such means to ensure the hardening of the concrete before freezing, or the time consumed in carrying them

out, make it advisable as a business measure to run a certain measure of risk with unprotected work. It is all a question of business judgment and the use of materials, such as quick-setting cement, warm sand and stone, and sometimes salted water, which will tend to minimize the chance of trouble. It may be advisable to run the risk of destruction of part of a concrete work by freezing, and if such destruction occurs it is not necessarily an indication of poor engineering.

The Victoria Falls Transmission.

Last week this journal reported the placing of a contract for the equipment of this huge project, of which much has been heard during the year. Of course The Engineering Record earnestly hopes that the work will go along merrily, but there's many a slip 'twixt the award and the installation in all large electrical projects, and in the absence of corroborative detail one can hardly be expected to consider the job as good as done. This journal has even heard doubts expressed as to the hydraulic conditions at Victoria Falls during a dry season. Aside from all such questions of fact, it is a great step to have advanced such a proposition from the realm of pure promotion to the dignity of even a tentative contract. For the project has this to distinguish it from all others, that it contemplates the transmission of an enormous amount of power over a line of more than double the length heretofore anywhere used, into a region of cheap coal. Success, if it crowns the enterprise, will be won in virtue of the enormous scale of the operations. There are few powers in the world that might admit of such treatment. Niagara is one, the gigantic cataract on the Parana another, and beyond these perhaps none will be found. Niagara, however, is temporarily, at least, out of the reckoning, for the power derived from it is much split up and utilized to no inconsiderable extent at nearby points. Niagara, although one of the few very great powers in the world, has not yet given rise to any very striking power transmission, and if the development there is to be rigorously limited, perhaps it may be many years before the way for the larger use is opened. The great South American fall is as yet untouched, though the capitals of four nations lie within reach of it, reckoning its reach on the basis of the great South African project.

The essential feature in any of these tremendous projects is the possibility of using under the stimulus of stupendous output a voltage for transmission that would not be feasible on a small scale by reason of expense for the necessary precautions. One can afford to spend a very large amount per mile on a system that is to deliver a corresponding large output. The same sort of problem arises in the consideration of plants working over shorter distances. It is practicable, for instance, to work at 50,000 volts, but it does not pay to do so for a transmission of a few hundred horse-power ten or a dozen miles. The total saving of copper per horse-power is not enough to justify the added expense and risk, to say nothing of the copper demanded for any usual value of the loss being too small to string. When some thousands of horse-power are to be transmitted many miles the line becomes at best a very large item of cost, and the saving by increased voltage becomes very important. Now schemes like that at Victoria Falls are an extremely exaggerated case of the same sort of thing, with this dubious factor, that nobody yet knows what the extra cost of building a line for 150,000 or 200,000 volts is going to be, granting that it can be done at all. We have as yet seen no data on tests at anything remotely approaching the voltage necessary

for success in such a case. Until such data are secured one may well feel some hesitancy in speculating upon the probable financial outcome. The actual voltage of electrical power transmission has not risen materially for the last five or six years so far as the maximum is concerned, albeit the average has increased considerably. Once the feasibility of 100,000 volts or more is firmly established there will arise entirely new possibilities in transmission. There is hardly a large city in the world that is not within, say, 500 miles of hydraulic power sufficient for a profitable transmission, if the necessary voltage is available. It is necessary, however, to do an immense amount of experimental work on a very large scale before the issue of practicability is settled. And thus far, at least, the Victoria Falls project should lead to the world's great good.

Mr. Roosevelt Praises the Panama Canal Work.

The chairman of the Isthmian Canal Commission asserted in a speech some months ago that the Panama Canal was essentially a Roosevelt enterprise, and the truth of this remark was emphasized by the recent visit of the President to the Isthmus, a journey unprecedented in the country's history. In view of the record of the President with regard to this great undertaking, the special message concerning it which he sent to Congress on Monday is a document of such interest that it is printed in full elsewhere in this issue, together with a number of the pictures he transmitted at the same time. Lack of space alone prevents the reproduction of other pictures, showing views along the line and various ceremonies in which our chief magistrate was the leading figure. It has also been impracticable for the same reason to reproduce the various appendices to the report. It is believed, however, that the text of the message and the pictures which are published in this issue will be sufficient to give the reader a complete presentation of Mr. Roosevelt's opinions.

The greatest interest in the message among engineers, of course, lies in the statements concerning the type of canal. The President is careful to point out that his stay of three days' duration was not sufficiently long to enable him to pass judgment on the engineering problems, but "an inspection on the ground at the height of the rainy season" convinced him "of the wisdom of Congress in refusing to adopt either a high-level or a sea-level canal." As the Isthmus is merely a little neck of land and was visited by Mr. Roosevelt at the worst time of the year, it is manifest that three days' diligent sight-seeing would be ample to enable anybody of such quick perception to determine on the spot by observation the best plan for the canal. There are, of course, some details that remain to be settled, particularly regarding the Gatun dam, the La Boca dams and the Culebra cut, and it is interesting to note that the President is of the opinion the building of the locks and dams will take even longer than the excavation of the Culebra cut, a view which met with some criticism when expressed by this journal more than a year ago. It is apparent from the wording of the message that the problem of the Gatun dam and locks will remain somewhat unsettled until next spring, when Secretary Taft and Messrs. Noble, Stearns and Ripley are to make "the final and conclusive examinations as to the exact site for each lock." The President himself is entirely satisfied with the practicability of the dam, although he believes there will be some little risk in connection with the work. The "artificial mountain thrown across from one foothill to the other will probably show less seepage than the average natural

mountain range," he states. As the whole practicability of the project in hand, entirely apart from its advisability, depends on this dam and the locks for which a site has not yet been definitely determined, the importance of Mr. Roosevelt's decision on the subject, after personal examination of the conditions at Gatun, is too apparent to require comment. The President's comments on the Culebra cut are equally convincing. Although damage is likely to occur from occasional landslides, these incidents will not be what may be called major disasters, and "it was striking and impressive to see the huge steam shovels in full play, the dumping trains carrying away the rock and earth they dislodged." The work is going on so efficiently, in fact, that it was possible in one place to greet Mr. Roosevelt with a presidential salute of 21 charges of dynamite. The President's well-known conservatism is thoroughly shown in his acknowledgment that there are bound to be delays and accidents in the prosecution of such an undertaking, and we may all feel well encouraged by his optimism in the face of this prospect. "There will be unlooked-for accidents to delay the excavation of the cut or the building of the dams and locks," he says, "yet each, when discovered by sensation mongers and retailed to timid folk of little faith, will serve as an excuse for the belief that the whole work is being badly managed."

Almost as interesting to the engineer as the type of canal is the sanitation of the Canal Zone, for on the successful maintenance of sanitary conditions depends the steady prosecution of construction. This subject received careful attention by the President. But one mosquito was seen by his party, and that one fortunately not of a dangerous species. In order that Congress might have absolutely reliable information on the subject, the highest official of the land did not consider it beneath his dignity to inspect personally numerous water-closets for both white and colored laborers. In one case very bad conditions were discovered, and the message is accompanied by a special report by Dr. Gorgas on this unfortunate discovery, which, to judge from the attention it received in the message, was decidedly disturbing to the President. Naturally enough Mr. Roosevelt paid special attention to the negro laborers, as the difficulty of exercising a thorough supervision over them is greater than among whites, and they are less competent to care for themselves. Apparently they are only fairly satisfactory, as a class, for "thousands of those who are brought over under contract, at our expense, go off into the jungle to live, or loaf around Colon, or work so badly after the first three or four days as to cause a serious diminution of the amount of labor performed on Friday and Saturday of each week." Evidently the difficulty of keeping them and their surroundings in a good condition is likely to be a troublesome undertaking, and it is not surprising to learn from the President's message that other nationalities than West Indian negroes are strongly desired for unskilled laborers. The sanitation of the cities and towns in the Canal Zone is warmly praised in the message, which states that the conditions as regards sickness and the death rate compare favorably with those of reasonably healthy localities in the United States. Paving, sewerage and water supply in Panama and Colon have been vigorously pushed, although these cities are outside the Canal Zone; the water supply of Colon is particularly approved, for the President examined it by the crucial test of drinking it and pronounced its quality excellent. Wherever the conditions were not entirely good, they were being bettered, or the President was told that plans had been already prepared for immediate improvements, and consequently he is satisfied that "the right course

to follow was exactly the course which has been followed. Every reasonable preparation was made in advance, the hygienic conditions in especial having been made as nearly perfect as possible; while on the other hand there has been no timid refusal to push forward the work because of inability to anticipate every possible emergency, for, of course, many defects can only be shown by the working of the systems in actual practice."

The portions of the message relating to the housing and food of the men on the Isthmus are particularly important. This matter was investigated at the Isthmus for The Engineering Record last summer, and the conditions then were decidedly good, as stated in the issue of Oct. 27. The President makes the same report, and his message is accompanied by numerous photographs of the exteriors and interiors of permanent and temporary quarters. These illustrations, some of which are reproduced elsewhere in this issue, tell their story better than many columns of text. As for the meals, Mr. Roosevelt tried them at places where his visit was not expected, he states, and found them good. The food supplies for the negroes have given rise to much complaint, which the British consul stated to the President was unwarranted, as were other complaints from the West Indian laborers. One of the greatest needs at present is to provide amusements both for the white men and the black, the President states, and he specifically called the attention of the Commission to the matter. It has not been generally understood that Mr. Roosevelt had any extended personal knowledge of construction work, but he states, "From my own experience, I am able to say that more care had been exercised in housing, feeding and generally paying heed to the needs of the skilled mechanics and ordinary laborers in the work on this canal than is the case in the construction of new railroads or in any other similar private or public work in the United States proper." In view of the sweeping nature of this official commendation and the known excellence of the accommodations provided on many contract undertakings in this country, the subject should be considered pretty well settled.

Toward the close of the message the President pays his respects to those who have indulged in reckless slander regarding this great work. His vigorous words deserve hearty applause. "Where the slanderers are of foreign origin I have no concern with them," he says. "Where they are Americans, I feel for them the heartiest contempt and indignation; because, in a spirit of wanton dishonesty and malice, they are trying to interfere with and hamper the execution of the greatest work of the kind ever attempted, and are seeking to bring to naught the efforts of their countrymen to put to the credit of America one of the giant feats of the ages. The outrageous accusations of these slanderers constitute a gross libel upon a body of public servants who, for trained intelligence, expert ability, high character and devotion to duty, have never been excelled." This statement is none too strong. The President has been a ready and vigorous critic of many public affairs, and, of course, expects vigorous criticism in return from those who honestly hold opinions differing from his own. This journal differs radically from his views concerning the best type of canal, and the official data given out from time to time strengthen its belief that the adopted plan is by no means the best. Yet The Engineering Record is in full accord with the President's condemnation of a considerable portion of the criticisms of Isthmian conditions, and agrees heartily with his statement that participation in the undertaking will later be a proud memory to those who help dig the canal.

The Pollution of Water Supplies by Railways.

At the last annual convention of the New England Water Works Association, Prof. W. T. Sedgwick discussed in his presidential address the important subject of the protection of public water supplies from pollution during the construction, maintenance and operation of railways. The address was accompanied by voluminous appendices bearing so directly on it that it has not been practicable to review the subject properly until now, when the entire paper can be studied in the "Journal" of the Association. The eminent position of the author and the serious danger of this kind of pollution in the case of a few cities combine to make his address a valuable one. Forewarned is forearmed among intelligent men, and the paper sounds a strong note of warning against lax sanitary regulations regarding railway trains and railway property within the drainage areas of municipal water-works. Theoretical studies did not suggest it as a topic of discussion, but it resulted from a very strong popular outcry in Seattle against the possible pollution of its water supply.

In the Pacific extension of the Chicago, Milwaukee & St. Paul Ry., described on page 687 of this issue, the line runs for 11 miles very near the Cedar River, whence the city's water is drawn. A large part of the land along the river is owned by the city, and it was proposed to secure the necessary right-of-way by means of a municipal ordinance, prohibiting the construction of stations along this strip without the city's consent and providing for the exclusion of all polluting matter from the water during and after the construction of the road. The proposed ordinance was a great advance in its sanitary requirements over anything previously drawn up, and all those concerned in its preparation were congratulating themselves on having agreed on requirements far more stringent than anything before adopted, when a vigorous protest against it began to appear. The people of Seattle take great pride in their water supply, and they rose en masse to defend it. Social and political clubs, the Chamber of Commerce, and other organizations protested against the ordinance, and finally the county medical society obtained an injunction restraining the mayor from signing the deeds. The railway authorities were thus compelled in self-defense to retain experts to investigate the problem of constructing the road and operating the trains in the valley in such a way as to keep the water free from pollution. Mr. John W. Alvord, of Chicago; Professors Pammel and Bissell, of Iowa State University; Prof. E. G. Smith, of Beloit College, and finally Professor Sedgwick were thus retained. Mr. Alvord found that the drainage basin was already being polluted from various logging camps and mills in a dangerous manner. Mr. John R. Freeman was waylaid while passing through the city on his way to Alaska and persuaded to investigate the subject for the State Board of Health. Finally, it was agreed to leave the decision to a commission consisting of Prof. A. C. Abbott, of the University of Pennsylvania; Prof. Charles Harrington, of Harvard University, and Professor Sedgwick. These specialists reported that it was possible to construct and operate the road without danger to the water supply.

The reports of this commission and those by Messrs. Alvord and Freeman taken together are very instructive, but The Engineering Record is compelled to disagree with many of the statements in Professor Sedgwick's address. He advocates the use of sewage tanks or equivalent receptacles on passenger and freight trains, which can be emptied at regular stations. Their use is advised on the ground that nothing of the nature of closet wastes should be dropped on a railway

track. This journal believes that such a proposition is not only impracticable, but is also unnecessary. Such matter falling on a track is rapidly absorbed, for roadbeds are porous and well drained. It will do no harm except where the tracks are within the catchment areas of water works, and there is no reason for carrying a little cesspool on every passenger car and caboose to avoid the danger of pollution of water supplies along an infinitesimal fraction of the country's railway mileage. The desired end can be attained in a much better manner by special construction within each drainage basin that must be protected.

This last fact is well shown in the report of the commission of which Professor Sedgwick is a member. Wherever the soil between the roadbed and the body of water is devoid of those properties which make it an efficient filter, the roadbed can be trenched and the trenches filled with gravel and sand, and dikes can be constructed along the ditches to prevent surface wash. The bridges can have steel decks ballasted with gravel and sand and drained to points beyond the river banks where the discharge from the pipes can be received on areas of suitable natural soil or artificial filters. Construction camps can be maintained in a sanitary condition which will keep the water supply free from contamination, and the men engaged in maintenance work can be made to take an intelligent interest in preventing pollution from their own huts and also by occasional visitors to the district. These are all things that can be done efficiently, as the commission points out, but at the present time the individual cesspool for each car, recommended by Professor Sedgwick, is an impracticability, and its suggestion will probably lead many railway officials, if they hear of it, to consider car sanitation as a scientific nightmare.

Possible Savings in the Cost of Reinforced Concrete Work.

That the reinforced concrete type of construction is still in the early stages of its evolution is patent to all who are conversant with it. That it has a great future is also undoubted. It is evident that a condition will ultimately be reached wherein style of reinforcing bar, types of reinforcement and designs of falsework will be as well standardized as are the corresponding points with regard to timber mill construction or steel structural work to-day. Real progress will be made most rapidly by those who keep constantly in view this standardization ideal. Such standardization will provide simple designs and methods of construction, thereby attaining economy in costs of materials and labor and in time of construction. At the present time the tendency seems to be toward new devices in all lines, special bars, special tricks of arrangement of reinforcement, and occasionally a special kind of form or centering.

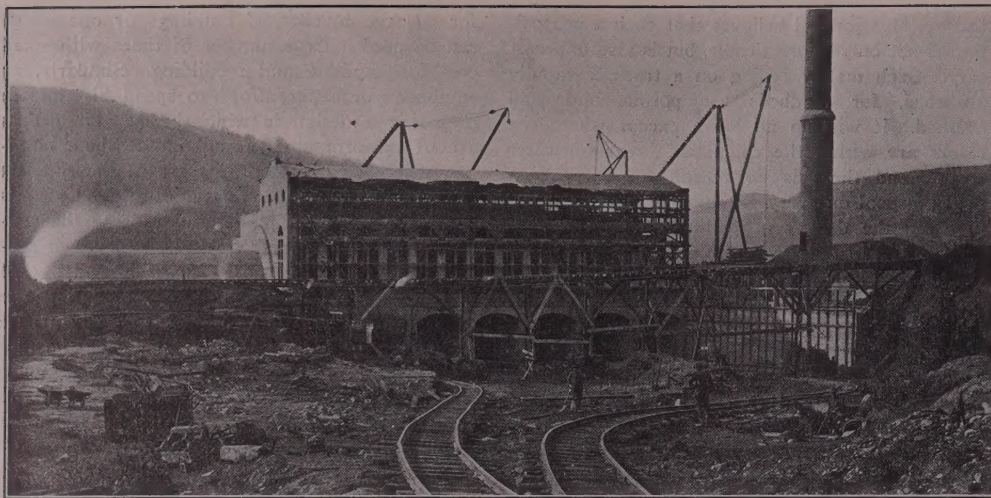
Any one examining the cost reports on most reinforced concrete structures can see the badly unbalanced condition of the relative costs of different parts of the work. This is notably true as to the relative cost of the falsework, both as to labor and material, and there is a strong tendency to cut costs by attacking this most prominent item. As much money can be saved by an experienced engineer for his client, or by a clever contractor for his pocketbook, by careful consideration of the details of falsework and general structural design, as by blind cutting of salient costs. Instead of reducing to a dangerous minimum the number and size of falsework supports or of removing them at the earliest possible moment so as to give them repeated use, a contractor can secure better results by giving his attention to working up a simple design of falsework which may become a standard

for a large number of buildings or one which can be used a large number of times with small cost for handling and rebuilding. Similarly, an engineer can better afford to spend his time in preparing a design in which beams and girders are of uniform size throughout a whole building, where structural details are of the simplest nature and where few varieties of rod details are necessary, than in determining the theoretically most economic shape and size of each separate beam to a quarter of an inch, and of rod spacings to a sixteenth, or of computing the necessary area of reinforcement in a given case to a thousandth of a square inch, when the mill exacts of each buyer a promise of acceptance with a possible variation in weight of each rod from the standard of 5 per cent., and where a single shipment may contain material with elastic limits varying more than 10 per cent.

Simplification of architectural design can be made another fruitful source of saving, and this, too, without aesthetic loss. The man who will originate a pleasing style of architecture, adapted to easy construction in reinforced concrete, will be a real benefactor, and incidentally will find a most remunerative field. At the present time, few engineers and architects understand the requirements of easy concrete construction well enough to appreciate what heavy expense is often entailed in working out in concrete what is easy and beautiful in wood, metal or cut stone, but what is entirely misplaced when the qualities of concrete are considered.

Many structural features necessary in timber or steel construction prove costly in concrete, and are really unnecessary when that material is employed, because of the absolutely monolithic nature of a concrete structure when properly reinforced. Omission of such details is a very productive source of small savings which often aggregate a very considerable amount, if carefully considered. For instance, one extremely important point with regard to costs in concrete building work is the design of floor openings so as to simplify erection and minimize the number of sizes of beams and girders and their reinforcing members. Very often inexperienced architects and engineers lay out pipe shafts, stair wells, and other openings, so as to cut directly across the most economic direction of running reinforcement. This action necessitates extra header and supporting beams, usually of small size, with all the expensive work attending the framing of the falsework for them. Such miscellaneous work often takes as much time as the erection of the whole of the remainder of the floor, and almost invariably, careful consideration will provide a different design which can be erected rapidly and cheaply and be fully as satisfactory from an æsthetic point of view.

Why the old beam and girder type of construction found necessary for timber should have been adopted at first so widely for concrete, can be explained only through a lack of appreciation of the new material. The economies which result from the adoption of other designs are forcing their notice on the engineers who are also contractors, and their general adoption of such designs will eventually take place. Meantime, unscrupulous owners and contractors are taking other methods of lessening costs, to their own risks and the present damage to the growth of a great development. Inventive genius and care in design can combine to make legitimate reductions in cost and time of erection which will be much more effective. Instances are on record of reductions as great as 25 per cent. where experience was combined with the two elements mentioned, and probably equal savings in first cost can be realized under many conditions. It therefore behooves all designers to look carefully to all points in regard to which ease of construction can be increased.



Power House from the Tail Race.

THE WARRIORS RIDGE HYDRO-ELECTRIC PLANT AT HUNTINGDON, PA.

DETAILS OF A COMBINED HYDRAULIC AND STEAM PLANT OF 8,000 HORSE-POWER.

The Juniata Hydro-Electric Co. was organized to undertake the development of several important water powers on the branches of the Juniata River, and is now engaged in the construction of two hydro-electric plants in Warriors Ridge Gap, above Huntingdon, Pa. The main plant is near Warriors Ridge station and the other $2\frac{1}{2}$ miles farther down the river, toward Huntingdon. The work was begun Oct. 1, 1905, and will be completed about the last of next month. The development includes the construction of an Ambursen dam nearly 400 ft. long, securing an effective head of 28 ft.; a 30x205-ft. reinforced-concrete power house, with two wings, 78x45 ft. and 78x26 ft., respectively; and the installation of a combined hydraulic and steam plant which will be capable of generating, when the installation is complete, about 8,000 h.-p. The estimated cost of the plant at Warriors Ridge is approximately \$425,000, while the total cost of the two developments, including transmission lines and sub-stations, will be in the neighborhood of \$1,000,000.

The main plant is located four miles west of Huntingdon, Pa., on the Juniata River, at a gap in Warriors Ridge range, through which the Pennsylvania R. R., the old State canal and the river all pass. The river, flowing in an easterly direction, runs close to the south side of the gap with the old canal skirting its north bank. The railroad crosses the gap at its north end in a direction parallel to the river. Between the two is a nearly level area about 1,000 ft. wide. The canal was abandoned years ago. It was originally

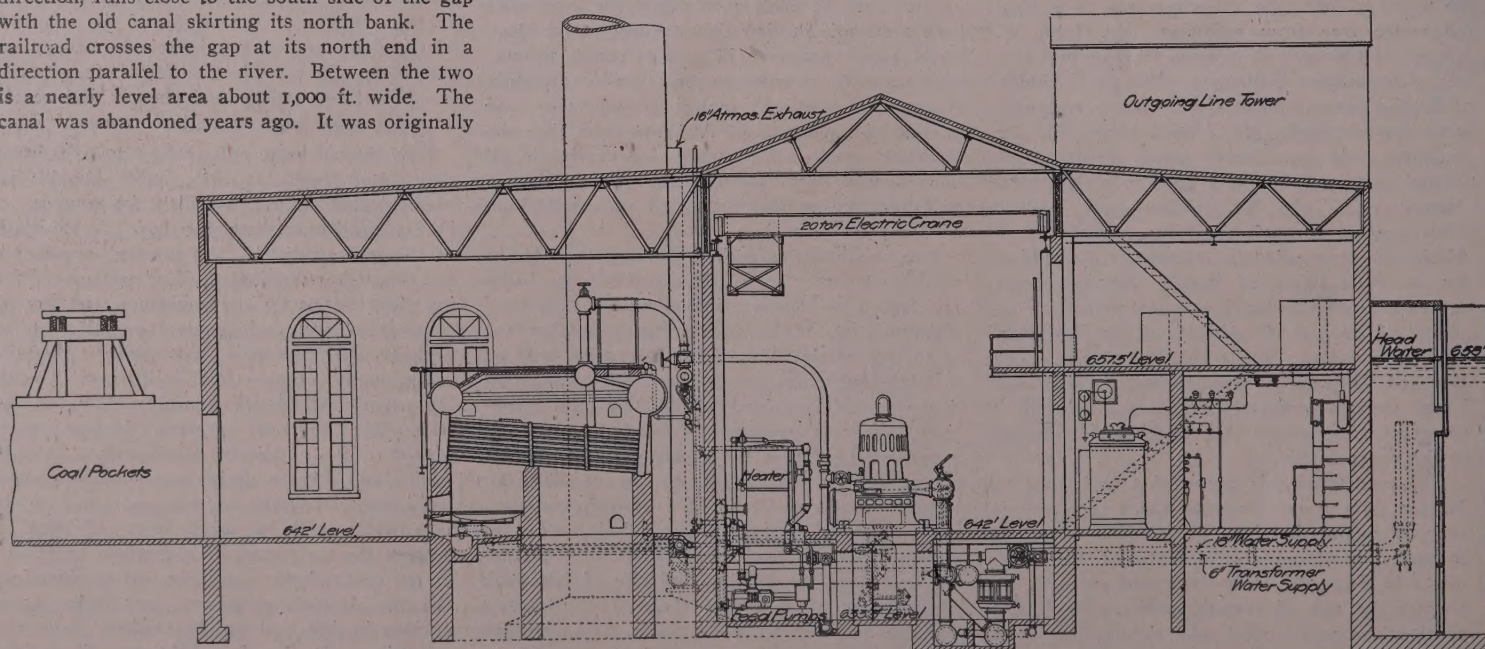
only a small affair 30 ft. wide with 4 ft. of water and the power house of the new plant stands on its line. The river bed is so deep that ordinary high water will be confined entirely within the natural banks at the dam site and only when more than 4 ft. of water is flowing over the crest of the dam will there be any flow over the level area between the river and the railroad. This area may be sold for factory sites, and to guard against its inundation a low dike nearly 800 ft. long and having a maximum height of 70 ft. has been built extending in a northwesterly direction from the power house.

The drainage basin supplying the river above Warriors Ridge is about 900 square miles in area and the fluctuation between the dry and wet season flow is considerable. It was, therefore, deemed advisable to install a steam auxiliary plant, capable of meeting deficiencies in water power at the Warriors Ridge plant and the second hydro-electric plant, which will be operated on multiple therewith, as well. The intention is at present to supply from the Warriors Ridge plant 4,000 h.-p. generated by hydraulic power, with two 500-kw. steam turbo-generators to furnish the additional power required.

The soil at the site consists of clayey gravel

underlaid, at about El. 625 to 630, by a soft, black, slaty material which resisted pick and shovel and was removed wherever necessary by blasting. In all about 55,000 cu. yd. of material had to be excavated. The lowest bid received for steam shovel work was 65 cents per cu. yd., and as this was believed to be high the company bought a 13-ton Vulcan locomotive and a number of small cars and handled the excavation by day labor. The cost per cubic yard has never reached 60 cents and averages about $37\frac{1}{2}$ cents. The excavated material is wasted in the old canal bed below the tail race.

The Dam.—The designs for the reinforced-concrete dam were prepared by the Ambursen Hydraulic Construction Co., which also furnished the construction plant and a skilled superintendent. All labor, material and small tools were supplied by the Juniata Hydro-Electric Co. The dam extends across the river in a nearly north and south direction, the south end abutting against the foot of Warriors Ridge and the north against the power house. It has a rollway 375 ft. long and is $57\frac{1}{2}$ ft. wide from outside to outside of cut-off walls. The height, measured from the bottom of the dam floor to the crest, varies somewhat owing to the floor being stepped up or down depending on the nature of the bearing material. The maximum height is $27\frac{1}{2}$ ft. and the minimum $22\frac{1}{2}$ ft. The elevation of the crest is uniformly 658 ft. An accompanying illustration shows the cross-section and general dimensions of the dam. The cut-off walls extend down to the black slate, but the floor rests on the natural bed of gravel contained between the cut-off walls. The buttresses are 10 ft. center to center. From the top of the floor to El. 644 they are 18 in. thick, but at this elevation they are reduced to 14 in. by a 2-in. offset on each side. In each bay weep holes are provided in the floor to relieve upward hydraulic pressure and a drain pipe through the concrete below the "bucket" or toe carries off seepage water. In each buttress are two rectangular openings. A plank walk carried through the upper series of openings serves as a passageway for inspection of the inner surfaces of the dam. The lower openings are for construction convenience only. In front of the "bucket" or toe and extending the entire length of the rollway is a floor of boulder concrete, 2 ft. thick and 24 ft. wide, to prevent scour during floods. At the south end of the dam the two sections nearest the abutment wall are raised 10 ft. higher than the crest, thus forming a buttress.



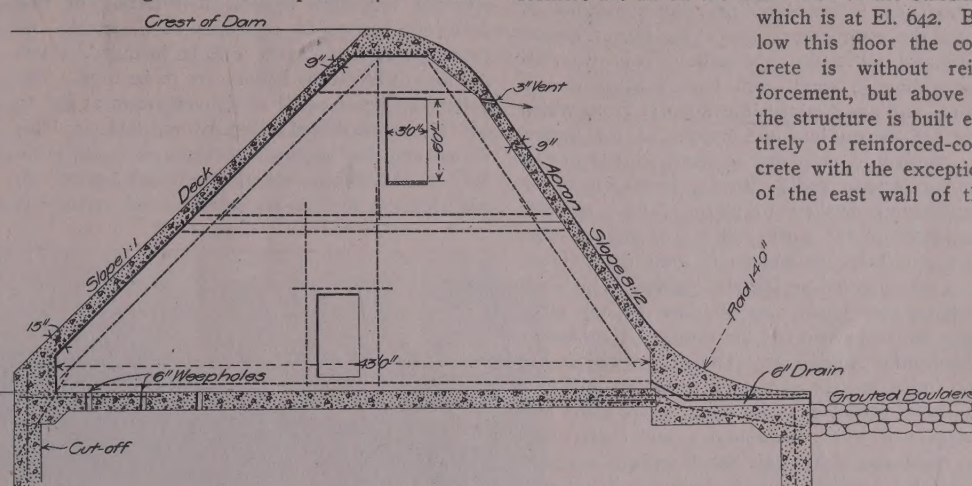
Cross-Section through Boiler, Steam Turbine and Transformer Rooms.

The abutment wall rests on the slate and is joined by the two cut-off walls of the dam. The ends of the abutment wall turn into the bank at an angle of about 45 deg. with the direction of flow, and are carried back into the natural material to cut off water which might filter through the earth behind the abutment. A third cut-off wall runs into the bank at right angles with the abutment near its center. At the power house end no buttress is provided, but extending above and following the form of the apron a shoulder 1 ft. thick projects beyond the plane of the power house wall and serves to deflect the water from the wall. This can be seen in the illustrations. Provision has been made for attaching flashboards by imbedding short pieces of gas pipe vertically in the dam crest.

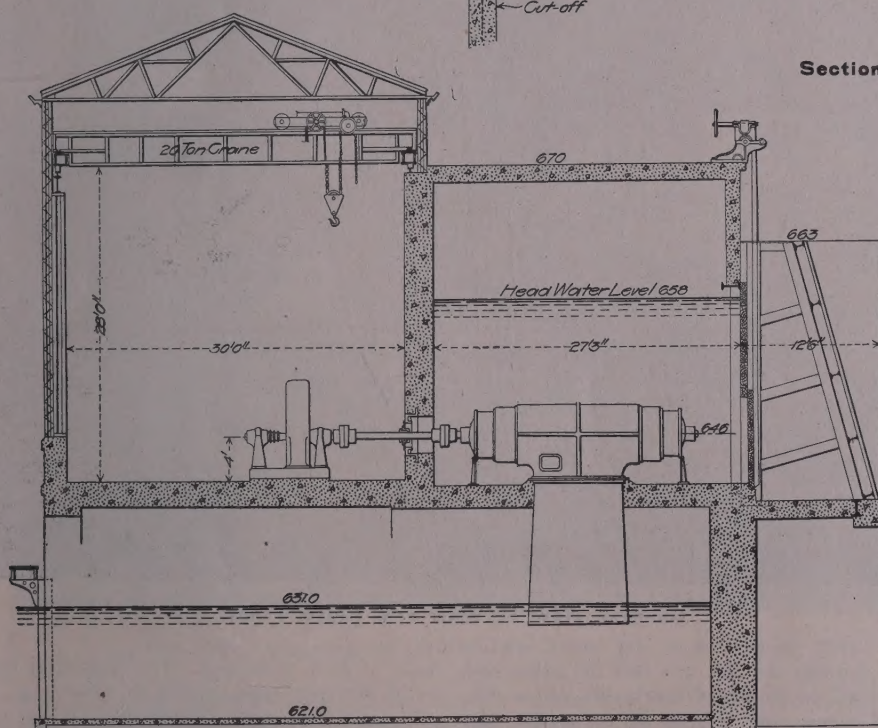
The concrete used in the buttresses, floor and cut-off walls is a 1:3:6 mixture, and in the deck, crest and apron the proportions are 1:2:4, the constituents being Whitehall cement, fine bank sand and screened, crushed limestone that passes a $\frac{3}{4}$ -in. ring. A Smith mixer supplying the entire work is placed near the north end of the dam on the downstream side and delivers concrete at about El. 638. During the construction of the northern portion of the dam the concrete was delivered by two stiff-leg derricks, operated by Mundy engines, from the mixer to a car running on a track over the tops of the buttresses. Later a 24-in. track was laid on a trestle along

the offsets. Similarly two horizontal rods extend through the center of the bottom portion of each buttress. These rods are 24 in. apart and are tied together with vertical rods, as shown in the illustration of the dam section. A single vertical tie rod extends through the center of each buttress. The deck, crest and apron are reinforced with horizontal rods placed near the inside surface. In the apron and crest the spacing is $6\frac{1}{2}$ in. In the deck it decreases from 6 in. near the crest where the pressure is least, to $4\frac{1}{2}$ in. at the cut-off wall, where the pressure is nearly at the maximum. The floor is reinforced in the upper surface with longitudinal bars spaced 24 in. center

north end of the dam. In the north end of this section is the steam turbine room, 30x78 ft. The remaining space is occupied by the hydraulically-driven generators. Attached to the central part of the building along the east side of the steam turbine room is a wing 78x45 ft., which houses the boilers. Directly opposite the boiler wing is another on the west side, 78x26 ft., which covers the transformers and the high-tension equipment. The central section has a pitch roof carried on steel trusses of the Fink type and the wings have shed roofs supported by Warren trusses. The generators, boilers, steam turbines and transformers are all on the main floor of the building, which is at El. 642. Below this floor the concrete is without reinforcement, but above it the structure is built entirely of reinforced-concrete with the exception of the east wall of the



Section of Ambursen Dam.



Cross-Section through Generator Room and Wheel Chamber.

the apron at about the elevation of the mixer and concrete was delivered in a $\frac{1}{2}$ -yard side-dump, push car to the derricks and by them hoisted to place in bottom-dump buckets. Nearly all the form lumber on the dam has been used six or seven times and a comparatively small amount has been required. The 2-in. offsets in the buttresses afforded a support for the molds for the upper portions of buttresses, deck and apron, and made it possible to remove the forms on the lower portions and move them up, using the concrete for support.

Three-quarter-inch Johnson corrugated bars are used throughout the dam for reinforcement. Each buttress has around its deck and apron edges two rods, one in each corner. Just over the upper passageway openings two horizontal rods extend across the buttress, one in each side. At the offsets are two horizontal rods in the center of the wall and 18 in. apart, one above and one below

to center and with transverse bars spaced 30 in. center to center. In the lower surface the floor has only longitudinal bars spaced 12 in. center to center. The cut-off walls have in the center horizontal rods spaced 36 in. and vertical rods 30 in. center to center.

The coffer-dam work incidental to the construction has not been unusual, but the method to be used in effecting a closure is interesting. In six bays the lower portions of the apron and deck walls have been omitted and the water passes through over the dam floor. When these bays are to be closed 8x8-in. stop logs will be placed horizontally across the buttresses to shut off the water while the forms are built and the concrete placed from within the dam.

The Power House.—The main section of the power house is 30x205 ft. in plan and 28 ft. high from the floor to the lower chords of the roof trusses. Its south end abuts squarely against the

generator room and the portion of the west wall above the dam wall in front of the turbines. These two walls are formed by vertical I-beam columns with expanded metal and plaster on both sides.

There are eight wheel flumes between the south end of the building and the south wall of the electrical wing. The two nearest the wing are for exciter turbines and are only 6 ft. wide. The remaining six are for the generator turbines and each is 15 ft. wide. The other dimensions of the wheel chambers are shown in the illustrations. The pier heads extending beyond the flume walls support the trash racks. Since the west wall of the electrical wing will be subjected to external hydraulic pressure it is reinforced with rectangular counterforts 2 ft. thick extending 11 ft. 3 in. beyond the building and spaced 10 ft. center to center. The ends of the counterforts are on the same line as the pierhead ends, and the tops of pierheads and counterforts are at the same height, El. 663. The spaces between the counterforts are to be filled with earth and a roadway built over them. A 3-ft. sidewalk is to be carried along the tops of the pierheads.

On the east side of the boiler house are eight coal pockets, over the tops of which a trestle track is to be run from the Pennsylvania R. R. The total storage capacity is about 5,000 tons, within easy shoveling distance of the boilers. The coal is delivered to the boiler room floor through doors with hinged gates by which the flow can be regulated.

The entire roof of the power house is constructed of cinder concrete 4 in. thick, reinforced with expanded metal, 10 gauge, 3-in. mesh, and is to be covered with tar and gravel. The gutters are constructed of expanded metal heavily plastered on both sides with cement mortar and lined with copper.

Ransome bars are used throughout for wall and floor reinforcement. The 3-ft. partition walls of the wheel chambers have $15/16$ -in. vertical bars in both sides, spaced 4 in. center to center. The dam wall in front of the turbines is reinforced with $7/8$ -in. horizontal bars spaced 4 in., for 12 ft. above the floor, and 6 in. the remaining distance. The 18-in. slab covering the chambers has 11/16-

in. bars placed longitudinally 4 in. center to center. The floor is 27 in. thick and is reinforced with 1-in. bars 6 in. center to center. No expansion joints are provided in the dam wall of the building, but the reinforcing rods are cut 18 ft. long and the ends are butted together opposite the center of each flume wall, so that if cracks appear they will be at these weak places. The flume walls are securely tied into the dam wall on each side of the weakened part.

The concrete used in the sub-structure is a 1:2½:5 mixture while in the reinforced work the proportion is 1:2:4. The constituents were the same as were used in the dam concrete. One Chicago cube mixer placed near the exciter flumes serves the entire work about the power house. The stone and sand are brought in from the railroad siding in small cars hauled by a dinky engine, and are dumped into hoppers from which they are drawn into the hopper of the mixer. The concrete is delivered at about El. 642 to two stiff-leg derricks and by them is hoisted in ¾-yd. dump-bottom buckets to place. These derricks were built on the work and are of unusual size, the booms being 78 and 80 ft. long, respectively. They are operated by Mundy engines. The work on the power house was all done by day labor under the supervision of the company's engineers.

Hydraulic Equipment.—Though provision has been made for six generator turbines, only four are to be installed at present. Each main unit is a pair of 39-in., horizontal, cylinder gate, central discharge S. Morgan Smith wheels, mounted on an 8-ft. cast-iron draft box and direct-connected to the generators. The wheels operate at 200 r.p.m. and each unit is guaranteed to develop 1,000 h.-p. when working at full gate under 27-ft. head. Each of the exciter units is a pair of 15-in. Smith wheels of the same type, guaranteed to develop 150 h.-p. under the same conditions. The draft tubes are all 13 ft. long and those for the generator units are 8 ft. in diameter at the top and 9 ft. at the bottom, 2 ft. below the surface of the tail water. Each turbine unit is coupled in its compartment to a shaft passing through the front wall to the generator. The entire turbine or any of its parts can be detached at the coupling and hoisted up to the top of the bulkhead through a 15x8-ft. hatchway. A small derrick is stored on the bulkhead for this purpose. With the same derrick the machines can be hoisted from or lowered to the driveway over the counterforts along the electrical wing.

The headgates for the 39-in. wheels are telescopic in form, as shown in the cross-sectional illustration of the generator room and flumes. The lower section is made of 8x12-in. logs and the upper of 6x12-in. In opening the gates, only the lower half is lifted until brackets at its bottom engage the bottom of the upper section. The two sections slide in separate grooves. In closing the gate a similar arrangement forces the upper section into place. In each lower section is a 14x14-in. filling gate, through which water is admitted to the wheel chamber and the pressure equalized when the gates are to be lifted. The gates are operated with double-stem hoists. For controlling the cylinder gates of the main generator units, Lombard type Q governors will be used, and for the exciter units type D Woodward governors are provided.

All the electrical equipment is furnished by the General Electric Co. Four 50-kw., 3-phase, 60-cycle generators are to be installed at once, and provision is made for two more similar units. These generators are of the horizontal-shaft, revolving-field type and, being direct connected to the hydraulic turbines as previously indicated, operate at 200 r.p.m. They are guaranteed to endure a 50 per cent. overload for two hours with a rise in temperature not exceeding 55° Cent. The generator voltage is 2,300, and the guaranteed efficiency under normal load is

97 per cent. The two exciter units are 75-kw., 125-volt, compound-wound machines running at 550 r.p.m. Either exciter is capable of furnishing excitation for the complete installation. In case of trouble with the exciter turbines, due to anchor ice, provision is made for the installation of an induction motor to be direct connected to one of the exciters at the opposite end of the shaft from the turbine. The exciter units are to be also used for operating a 20-ton, 3-motor electric crane having a span of 31 ft. and running the entire length of the building. This crane was built by Alfred Box & Co., of Philadelphia.

Steam Equipment.—Foundations have been constructed for four boilers in batteries of two each, one battery on each side of the stack. At present only one battery is to be installed. Atlas 400-h.-p. water-tube boilers are to be used. The boilers are guaranteed to deliver steam at 20° to 40° above saturated temperature, and for this reason and also because the steam plant will probably be idle except during low-water seasons no superheaters are to be installed. A sluiceway

a 20-gal. accumulator is being installed. The turbines have relief valves which discharge into a 16-in. free atmospheric exhaust pipe passing out through the roof. These machines operate at 1,800 r.p.m. and have the same guarantees as to overload capacity as the hydraulic driven units.

There are in the present installation two complete condensing equipments, one feed-water heater, and two feed-water pumps. The condenser auxiliaries are so arranged that any one of the set can operate with either condenser or in case of emergency one set can handle both condensers at a somewhat reduced efficiency. The condensers are of the Worthington, counter-current, surface type, having a cooling surface of 1,750 sq. ft. each, and are operated with Worthington center-crank, rotative, dry-vacuum pumps. No circulating pumps are needed, as the water for the condensers is taken directly from the head-water through an 18-in. pipe which is attached to a 16-in. header from which a 10-in. pipe supplies each condenser. By carrying the 16-in. discharge pipe under the surface of the tail-water the full



General View of Warrior's Ridge Plant.

passes through the ash pits and the ashes and clinker will be flushed through this into a perforated hopper with a dump bottom on the tail-race side of the boiler wing. The finer material will fall into the race, but the clinkers retained in the basket will be dumped into a scow and floated away. The water used in flushing out the ash pits enters through a 6-in. pipe under a head from the dam. The stack was built by the Weber Steel-Concrete Chimney Co., of Chicago. It has an inside diameter of 7 ft. and a height of 175 ft. above the boiler-room floor, and is designed to accommodate the final installation of four boilers.

The steam turbine room has foundations for four turbo-generators. At present two General Electric 500-kw. machines are being installed. The turbines are of the Curtis two-stage vertical type with cast-iron exhaust chambers in the base for bolting directly to the condensers. The step bearings are oil lubricated, two steam-driven oil pumps being installed, either one of which can supply the complete final installation. To provide against accidental stoppage of the oil pumps and the consequent damage to the stop bearings,

head of 28 ft. is secured. The feed-water heater is of the open type, rotated at 1,600 h. p., and will serve the complete installation. It was made by the Warren Webster Co., of Camden, N. J. The two feed-water pumps are each 9x6x10-in. duplex machines, made by the Platt Iron Works, and either one can pump hot or cold water or one hot and one cold simultaneously, if so desired. Two Worthington motor-driven, centrifugal pumps deliver water from the hot well of the condensers to the feed-water heater. The high-pressure steam piping is designed for 200 lb. working pressure and all fittings and valves are extra heavy.

The pumps and other auxiliaries, except the feed-water heater, are installed in the basement of the steam-turbine room on the side nearest the boiler-room. The elevation of this basement floor is 8½ ft. below that of the main floor. The operating floor is not carried over this side of the basement and the auxiliaries will be in plain view from the floor or the switchboard gallery. A bridge over the open basement affords a passage between turbine and boiler-rooms and supports the feed-water heater.

Electrical Features.—The generator voltage of 2,300 is stepped up to the transmission voltages of 11,000 and 45,000 by two banks of water-cooled, oil transformers. Each bank consists of three 500-kw. units and between the two banks is a seventh transformer which will act as a spare for either bank. Each transformer is enclosed in a separate concrete compartment protected at the entrance by rolling steel blinds. The construction is practically fireproof. The transformers are Y-connected on the high-tension side, and the 11,000-volt current is taken from the main winding by a tap connection. Water is supplied to the cooling coils of the transformers from the head-water, the discharge pipe being arranged like that of the condensers in the steam plant, in order to secure the maximum flowage.

The switchboard consists of twenty panels each 20 in. wide, of black Monson slate. It is supported on a gallery overhanging the west side of the steam-turbine room, 15½ ft. above the operating floor.

The low-tension cables from the generators are carried in fiber conduit laid in the concrete

culverts are carried on steel towers to the cities of Altoona and Tyrone, about 30 and 15 miles distant respectively. The towers are made of galvanized steel angles and support the cables at a height of 40 and 46 ft. above the ground. In general the towers are spaced twelve to the mile. They were built by the Riter-Conley Mfg. Co., Pittsburgh. Sub-stations are being installed at Huntingdon and Tyrone, and later one will be built at Altoona.

The power-house building and hydraulic installation was designed by the company's chief engineer, Mr. William H. Cushman, who is also in charge of the construction work. Mr. John P. McLean is first assistant engineer. The electrical installation was designed by the General Electric Co., which also acted as consulting engineers. Mr. John L. Curtiss is the electrical engineer in charge of installation. The steam auxiliary plant was designed by Mr. A. C. Wood, consulting engineer. Mr. M. H. Reed is superintendent for the Ambursen Hydraulic Construction Co. The construction of the transmission lines is in charge of Mr. F. W. Scott. The president and general

The Tidewater and Deepwater Railways Part II.

Princeton to East River.—At the summit of Oney Gap is a tunnel 1,650 ft. long, in rock, with an approach cut of 153,000 cu. yd. in rock at the west end, which is practically all within 2,400 ft. of the tunnel portal. At the east end of this tunnel is an approach cut of 30,000 cu. yd. in rock. The cut at the west end is being taken out with two 70-ton Bucyrus steam shovels which have their dippers equipped with Panama points to handle the hard rock that is encountered. The material is hauled out to the west in trains of narrow-gauge cars handled by small locomotives, and is utilized in a long fill. A single-stage Rand straight-line air compressor with a capacity of 800 cu. ft. per minute has been installed to furnish power to the drills that are used in making this cut and also power for other purposes. A 20-kw. Wagner generator driven by a Sturtevant automatic engine supplies electric power for lighting the work at night. A small trip-hammer driven by air is also installed and an air-driven deep well pump supplies water over the work.

The heading of the tunnel was driven from a shaft at the west portal and also in the regular way from the east portal. The material from the shaft at west portal was hoisted to the surface and wasted. That from the east portal was carried out and used in a big fill beyond the approach cut at the east. The bench was all taken out from the east end and was removed in two lifts. The tunnel was all in fairly good rock, but has been timbered its entire length.

The drills used in making blast holes in the tunnel were supplied with power from a single-stage straight-line Rand compressor in a power house near the east portal of the tunnel. This compressor operated at a 100-lb. pressure and air was carried from it to the headings through a 4-in. pipe line. A 20-kw. electric generator was also installed in the power house and supplied current to light the work in the tunnel and the approach cut at the east. The general contractor, MacArthur Bros. Co., has extended a standard-gauge railroad from the main line of the Norfolk & Western R. R. up the mountains to and about a mile beyond this tunnel, with a total length of 6 miles. The maximum grade on this railroad is 6 per cent. and the maximum degree of curvature is 30 deg. A geared locomotive is used in hauling cars up to the tunnel, all the supplies for the construction work in this vicinity having been brought in over this railroad.

From this tunnel at Oney Gap summit to the West Virginia State line at East River, a distance of about 16 miles, some of the heaviest construction work on the entire line has been encountered, including five high steel viaducts, six tunnels and much heavy grading work. The line follows down the valley of Rocky Hollow and Twelve Mile creeks to the East River, and thence generally down that river until it crosses it. In all of this distance it is up on the tops of the short irregular hills which make up the country, and it gradually drops from 200 ft. above the bottom of the tortuous, narrow valleys of these streams until it is about 120 ft. above the East River when it crosses that stream. In the first part of this 16 miles where the line follows down Rocky Hollow and Five Mile Creek to secure the best alignment possible and to maintain grades, the line is at varying distances back from the main valley, cutting through short steep hills and being thrown across the deep gulches that come between these hills. Thorough cuts are largely made through these hills except in cases where the hill carries out too far into the valley, and then a tunnel is driven.

The line swings around from the valley of



The Dam, Showing the Buttresses from the Downstream Side.

floor. The high-tension busses are of bare copper wire, separated by concrete barriers. These busses are not enclosed, as is often the case, but are left open to facilitate inspection. The three sets of bus bars are equipped with sectional oil switches and the outgoing feeders are divided between the two sections so that the station output can be transformed from one feeder to another. The low-tension switches are hand-operated and the 11,000-volt switches are solenoid operated, both from the board. The 45,000-volt switches are motor-operated, being also controlled from the board. All oil switches are placed behind the switchboard in concrete compartments. Multiplex lightning arresters are used.

The outgoing feeders are carried from a tower at the south end of the electrical room over the wheel pits to a heavy terminal tower at the south end of the building, and thence across the river to a similar tower on the south bank. The clear span is about 450 ft. Here the lines divide. Two 11,000-volt feeders run on a single line of wooden poles to Huntingdon, and a third runs on steel towers toward Altoona. Two 45,000-volt cir-

managers of the Juniata Hydro-Electric Co. is Mr. S. L. Brumbaugh. The general offices of the company are in the Perry Building, Philadelphia, the engineering and construction offices being at Huntingdon, Pa.

The Warrior's Ridge plants will be owned and operated by the Juniata Water & Water Power Co., a Pennsylvania corporation, of which Mr. H. L. Geyelin, of Philadelphia, is president. Philadelphia capital is largely interested in these developments.

AN OPERATING SIGNAL SYSTEM is in use at the Port Morris power station of the New York Central R. R., to indicate in the boiler-room which of the turbine generating units is in service. It consists of a large illuminated sign containing the numbers, 1 to 4, to correspond to the four generating units, and these are lighted automatically whenever a generator is started, and remain lighted as long as it is in service. The numbers in the signs have been made sufficiently large to enable them to be seen distinctly from all parts of the firing floor.

Twelve Mile Creek into that of East River through a tunnel 491 ft. long and follows along the valley of East River for nearly a mile until it enters a secondary valley back of the one through which the river flows. It follows this secondary valley for four miles and in this distance $1\frac{1}{2}$ miles of distance and a large amount of curvature are eliminated over what would have been obtained by following the river valley, the line being practically straight and on a uniform grade. To secure these results, however, it has been necessary to drive four tunnels through spurs of mountains that cut across the secondary valley. These tunnels have lengths of 465, 720, 580 and 560 ft. respectively in order, and are mostly through shale which disintegrates on exposure to the air. Outside of these tunnels the grading averages only 30,000 cu. yd. to the mile and alignment and grades that have been secured through the broken country are exceptionally good.

Hale's Gap Tunnel.—From the point where the line leaves this secondary valley it follows the East River again until the latter makes a long sweep to one side which is avoided by utilizing a pass called Hale's Gap, and driving a tunnel 2,000 ft. long through the summit of this pass.

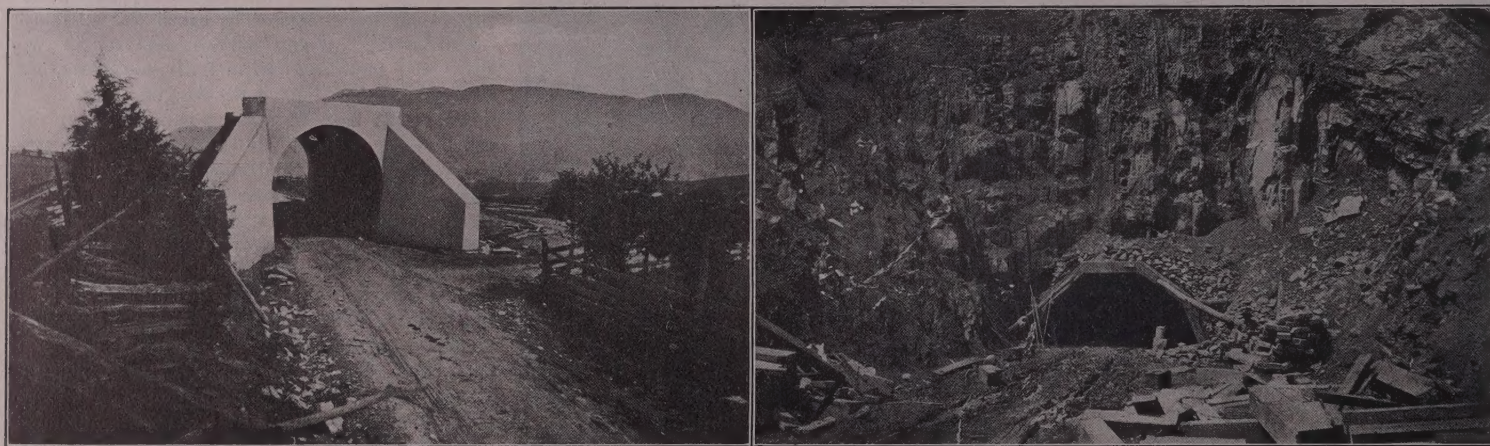
Two 13x22-ft. shafts have been sunk at this tunnel, one 350 ft. from one portal and the other 450 ft. from the other portal, and a heading is

each 500 ft. long, are taken off, one extending to each shaft. These branches are carried down the shafts as 4-in. pipes and thence to the headings as 3-in. lines.

An air-driven Lidgerwood hoisting engine with two 52-in. drums is installed at each shaft, each engine operating a pair of automatically controlled hoisting cages in the shafts. A special form of 3-yd. end dump car, built by the Western Wheel Scraper Co., is used in the headings in connection with these cages. Each cage consists essentially of a platform which carries the dump cars and is mounted on a steel frame that is hinged on a shaft under the transverse center line of the platform. The frame carrying the platform of the cage has a vertical channel on each side extending above the platform. These channels each fit over a lead attached to the timbering of the shaft and the cage is kept in line by them as it is raised and lowered. About 2 ft. above the level of tracks leading from the mouth of the shaft at the surface a section of the leads is omitted for a length of about $2\frac{1}{2}$ ft. and the guides on the frame of the cage are shaped so that the platform when it reaches the desired height is swung on the shaft on which it hinges. The door of the end-dump car is fastened to the top of the cage in such a way that when the car is tilted as the platform turns on the shaft, it opens and causes the contents of the car to be discharged

generally speaking are placed at points where fills could not be made economically. The first one of these viaducts is one and one-half miles from the Oney Gap tunnel at a point where the line crosses the valley of Rocky Hollow Creek. This structure has a maximum height of 120 ft. above the bottom of the valley and is 925 ft. long. The second viaduct spans the valley of Long Branch less than a mile from the first one. It has practically the same general dimensions as the first, both structures being 925 ft. long and with a maximum height of 120 ft. The third viaduct is two miles beyond the second one and spans the valley of Harmon Branch. It has a total height of 160 ft. and is 725 ft. 4 in. long, having the regular 30-ft. towers and 60-ft. spans, with the exception of an 80-ft. span over the stream and a 40-ft. tower at each end of this span. The fourth one of these viaducts has a maximum height of 60 ft. and a total length of 660 ft. It spans the valley of Five Mile Creek near the point where the line leaves the secondary valley of the East River to join the regular valley of the stream four miles from the Hale's Gap tunnel.

The fifth of this group of high viaducts includes a crossing of the East River and the main line of the Norfolk & Western Ry. This structure is 800 ft. long and has a maximum height of 140 ft. It has three 30-ft. towers and three



Concrete Arch for Undergrade Highway Crossing, and a Tunnel Portal in the East River Valley.

being driven from each of these shafts while heavy approach cuts to both portals of the tunnel are being taken out. A central power plant which supplies air under pressure for power to operate the drills in the tunnel, the hoisting cages, a heavy Atlantic steam shovel in the approach cut at the east and for various auxiliary machines around the work, has been installed on East River, about three-quarters of a mile from the tunnel and on the main line of the Norfolk & Western R. R. This plant contains five 100-h.-p. locomotive-type boilers built by the Nagel Engine Works, any four of which can furnish enough steam to operate the plant. A tandem-compound two-stage straight-line Sullivan air compressor and a cross-compound two-stage Rand air compressor, each with a capacity of 1,800 cu. ft. per second when operating at 100 lb. pressure, have been installed and are either one capable of supplying sufficient power to operate the plant under normal conditions. Each compressor exhausts into a Stilwell-Bierce open feed-water heater. Two 6x4x6-in. Gardner pumps supply feed water to the boilers. A Latta-Martin pneumatic pump placed in the river supplies water to the plant. A Sturtevant generating set supplies current to light the power house.

An 8-in. pipe line 4,300 ft. long extends from the power house up over a high steep hill to a point midway between the shafts at the tunnel. From the end of this 8-in. line two 6-in. branches,

through a chute into narrow-gauge side-dump cars in which the material is hauled out to waste banks.

A Sturtevant 20-kw. electric generator driven by a 7x7-in. duplex engine, operating on compressed air, is installed at one of the shafts and supplies current for lighting in the tunnel, around the head house of the shafts and along the steam shovel work in the approach cut. A Fuller automatic 6x6-in. air-driven engine direct-connected to a 9-kw. generator is held in reserve for the same service.

A 4-in. air line is continued from one of the shafts for 1,000 ft. to the approach cut at that end and supplies air pressure to operate a 70-ton Atlantic steam shovel and the drills used in making blast holes. The material from this cut is being hauled out to the east in 3-yd. cars by narrow-gauge Vulcan locomotives and utilized in a high fill near the East River crossing. When the tunnel headings are completed the bench will also be taken out by a steam shovel operating on air pressure.

Steel Viaducts.—The five high steel viaducts that are required from Oney Gap tunnel to and including the crossing of East River have regular 30-ft. spans and 60-ft. towers and are designed to carry a single track only. They have been located where the line crosses deep gulches between the abrupt hills through which the heavy rock cuts that have been mentioned are made, and

60-ft. spans alternately at the west end, then a 120-ft. deck riveted truss span over the stream, then successively a 40-ft. tower, a 75-ft. span, a second 40-ft. tower, and a second 75-ft. span over the tracks of the Norfolk & Western R. R., with two 30-ft. towers and two 60-ft. spans making up the remainder of the structure.

The Deepwater Ry. ends at the East River, which is the boundary line of West Virginia, its total length being approximately 114 miles. The first 27 miles out from Deepwater have been practically completed for from a few months to two years. Track is laid 70 miles from Deepwater and regular trains are in operation for 60 miles, between Deepwater and Mullens. The remainder of the grading from the end of track to the Bluestone River, including the tunnels, is nearly ready for track. Four of the high viaducts, 66, 68, 69 and 70, are still to be erected, but their erection will not delay the extension of track.

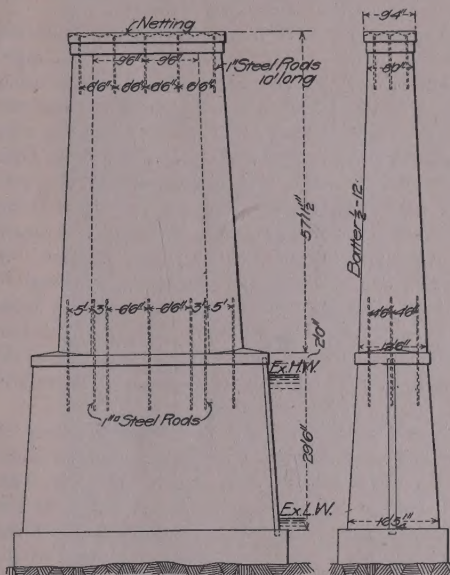
The construction work on the first 27 miles of the Deepwater Ry. was done by various contractors. The next 40 miles was built by Mr. D. A. Langhorne. Then the contracts for the next $18\frac{1}{2}$ miles were divided between the following contractors: the Rossi, Garland & Litz Co., 4 miles; Mason & Hoge Co., 5 miles, and W. O. Lipscomb, $9\frac{1}{2}$ miles. The remainder of the Deepwater Ry., including $28\frac{1}{2}$ miles from the Bluestone River to the East River, is being built un-

der a general contract with MacArthur Bros. Co. This latter company has in all contracts for 111 miles at this end of the line, the remainder extending from the East River to Roanoke, Va., on the Tidewater Ry.

East River to Allegheny Tunnel.—The East River passes around a sharp bend and joins the New River less than a mile below the point where the line crosses the former. At the crossing it is separated from New River by a short steep hill which rises very abruptly from both streams. A cut containing 100,000 cu. yd. of solid rock is being made through this hill in about 1,000 ft. of distance in order to hold the grade down to a reasonable height above the streams.

New River is crossed on one of the most important bridge structures between Deepwater and Norfolk. It has a total length of 2,145 ft. and consists of a viaduct approach at each end, with deck riveted-truss spans over the stream and over the main line of the Norfolk & Western R. R., which closely parallels the west bank of the stream. The side of the valley at the west drops away very quickly so that the viaduct approach at that end is short, consisting of two 60-ft. spans and two 30-ft. towers. This approach leads to a 125-ft. deck riveted-truss span over the tracks of the Norfolk & Western R. R., beyond which is another 30-ft. tower and then five 135-ft. deck riveted-truss spans over the stream.

removal of considerable quantities of material in short distances to secure a satisfactory alignment. Practically all of this work that has been done is of such nature that carts or cars are the most economical method of handling it so only a small amount of contractor's plant has been installed.



Concrete Pier of New River Bridge.



Views Showing West Portal and Power Plant and Head House at Shaft of Allegheny Summit Tunnel.

These trusses will be carried over the bed of the river by four concrete piers that will have a total height of approximately 96 ft., the details of one of these piers being shown in an accompanying illustration. The natural foundation at the site is all solid rock on which the footings of the piers will be built and will be carried up to uniform height. From the tops of these footings the piers are to have breakwaters on their up-stream ends, which will be carried up above extreme high water. Just above that level a coping is added and above this coping both ends of the piers are to round. The piers will be reinforced only as shown.

The east approach to the channel spans consists of twelve 30-ft. towers and thirteen 60-ft. spans placed alternately. The legs of these towers will rest on concrete pedestals carried down to rock. Several pedestals near the channel will be subjected to the current during the high water and are protected by starkwaters shod with iron.

The line follows the right bank of New River for nearly 40. miles from this crossing. In this distance it is on the average about 35 ft. above the stream and is ascending to the east on a water grade. For the most part the work in this distance is light, consisting largely in making a bench cut in the side hills of the river valley to carry the track. Occasionally a rocky hill juts out into the stream and requires the

Thirty-seven miles from the New River crossing the line starts to rise toward the summit of the Allegheny Mountains. This rise is continuous for 9 miles, the maximum grade being 0.6 per cent, compensated. The line leaves the river and follows up Strouble's Creek and Lick Creek, branches of the river, and then breaks across the country to the summit. Some heavy grading is encountered after the line leaves the river. About two miles from the start of the rise to the summit three pinnacles of rock, extending 120 to 135 ft. above the center line, had to be cut through in a short distance. From the cut through these pinnacles to the summit the line is largely on the side hills, and although no unusually large amount of grading is necessary, practically all of the cuts are in rock. One tunnel, 450 ft. long, also has to be driven before the summit is reached.

Allegheny Summit Tunnel.—The largest tunnel on either of the two railroads is being driven just east of the summit of the grade. It has a total length of approximately 5,140 ft. and is all through rock. The general contractors, MacArthur Bros. Co., have installed a very complete power plant near the mouth of a shaft about half way between the two portals of this tunnel and are carrying on the work with a day and night shift from four headings, having made about 2,500 ft. of progress from May 1 to Nov. 15. A

standard-gauge track has been laid up to the power house at the summit of the mountain from the line of a railroad operated by a local coal mine company and connected with the Norfolk & Western Ry. All of the construction supplies are brought in over this track which is about 2½ miles long.

The power house contains three 100-h.-p. and three 125-h.-p. Erie City tubular boilers which supply steam to three 20x24-in. Ingersoll-Sergeant air compressors. These compressors furnish air at 100-lb. pressure to operate drills in the four headings, hoisting engines, pumps, the machines in a complete repair shop, and various auxiliary plant used in connection with the work. A 6-in. air line is laid from receivers at the plant to each portal and is extended into the headings in a 4-in. pipe. A 6-in. air line is also extended to the bottom of the shaft and a 4-in. branch carried from the end of it to each of the two headings driven from the shaft.

The plant also contains a 45-kw. alternating-current electric generator, built by the Fort Wayne Electric Works and driven by a Buckeye automatic engine. This generator has a capacity of 800 32-c.p. lights and furnishes current to light the entire plant and the work in the tunnel. The machine shop of the plant is unusually complete for one of its class and all of its equipment is driven by air. It contains a heavy machine for sharpening drill points, a small trip hammer,

lathes and grinding machines, in addition to the usual small repair machines.

The shaft near the center of the tunnel is 12x20 ft. in plan and 130 ft. deep to the sub-grade of the tunnel. It is lined with 4-in. plank placed vertically and held in place by 12x12-in. rangiers. A pair of hoisting cages of the same type as those installed in the two shafts at Hale's Gap tunnel are used in raising material to the surface. The same type of end-dump car used at that tunnel are also employed in this tunnel shaft in connection with the automatic hoists. The cages are operated by an air-driven Lidgerwood hoisting engine with two 52-in. drums. The material from the shaft is wasted near the mouth of the latter.

A 20-in. Sturtevant blower, driven by an 8x10-in. engine operating on air pressure is set up at the mouth of the shaft and supplies fresh air to the headings through a 20-in. galvanized-iron duct extending to the bottom of the shaft and thence through a 14-in. duct laid down to each heading. An 18-in. Sturtevant fan driven by an air engine, is set up at the west portal and supplies fresh air to the heading at that end through a 14-in. duct. The east heading is ventilated by a 14-in. Sturtevant fan set up at the east portal and also driven by an air engine.

An approach cut in rock about 1,000 ft. long and containing 73,000 cu. yd. of material has been

practically all removed at the west portal. A 60-ton Atlantic steam shovel is working this cut in connection with trains of narrow-gauge dump cars.

The material from the heading and that part of the bench of the tunnel taken out from the west portal have to be wasted. A 1,200-ft. span Lidgerwood cableway, with 125-ft. towers, has been set up at this portal, with the tail tower out a short distance from the portal and the head tower up a small valley that makes an angle of about 30 deg. with the line of the tunnel. The cableway thus crosses the approach cut to the portal about 50 ft. from the latter and all of the material brought out of the portal is handled by it. The timbers used in lining the tunnel are also handled to the portal from storage piles along the track that has been extended up to the power plant from the track of the coal mine company. This cableway is operated by an air-driven Lidgerwood hoisting engine, with two 52-in. drums.

The skips used in connection with this cableway are of special design and are particularly well adapted for handling the material from the heading to the dump. They are built about the same as an ordinary steel skip used in connection with cableways and have a capacity of 3 cu. yd. Each skip is mounted on four wheels set in pairs to run on a 6-ft. gauge track. One end of the skip is open and the bottom being only 9 in. above the ground permits the men on the muck pile to load them without lifting, thus greatly facilitating the tunnel excavation work.

nel the line drops away to the east for 35 miles to Roanoke, following for 6 miles, first the valley of a stream called Mill Branch and then North Fork of the Roanoke River for 12 miles to its junction with the South Fork of that stream to form the latter. The Roanoke River is followed for 30 miles from this junction to a point 10 miles east of Roanoke, Va.

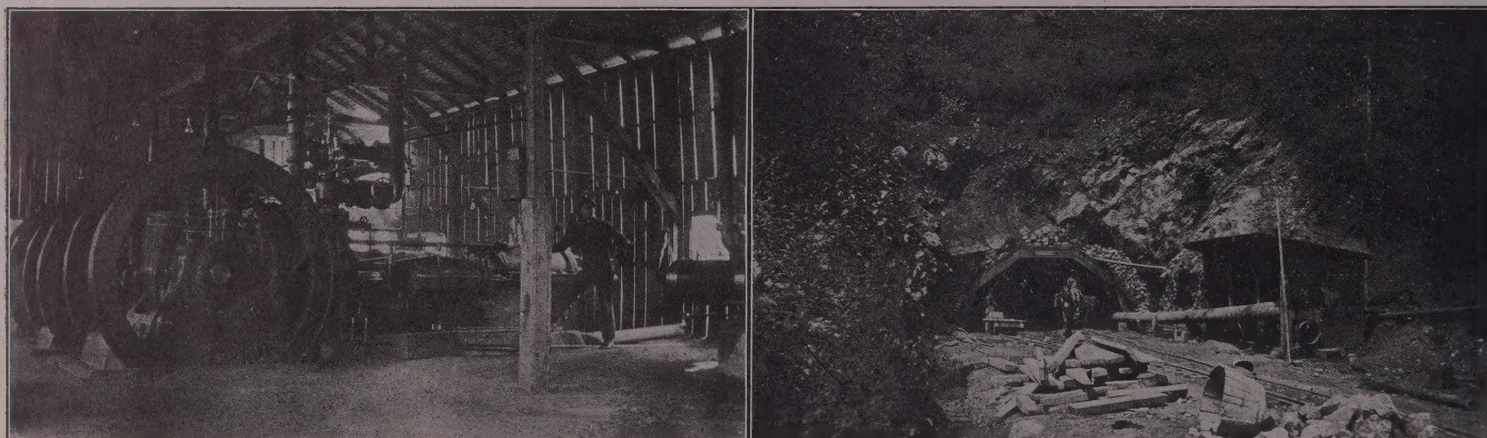
The grading work in this drop down from the summit of the Allegheny Mountains is not especially heavy, although for the first twenty miles the country is broken and mountainous and the valleys of the streams that are followed are very crooked, nevertheless a good alignment has been secured. Through this rough country the cuts are mostly all in rock and the grading is being handled largely with carts, although two steam shovels are in operation in this distance. A tunnel, 830 ft. long, is being driven through a hill of slate-like sandstone about 10 miles from the Allegheny summit tunnel. Eleven stream crossings most of which are plate-girder spans are included in the construction down the valleys of these small streams.

The line crosses over the Roanoke River at the end of this rough country and follows down the valley of that river, which valley is from one-half to two miles wide at this point, and is probably the widest one that has been utilized between this point and Deepwater, as most of the valleys of the mountain streams are deep, narrow and tortuous. The work down this valley to Roanoke is all comparatively light, and the heavy-

tervals and the regular low grades on the main line track a large number of long heavy trains can be handled with a minimum of operating difficulties.

Water tanks are placed at intervals of about 30 miles and locomotive coaling stations at intervals of about 60 miles. A standard design of elevated storage pockets has been adopted for the coaling stations. This design is made so the only portions of it which need to be modified at different locations is the length of the incline approach carrying a spur track up over the pockets. The number of pockets may easily be made as great or as few as is desired. Timber is thus more readily secured and cut and erection is simplified.

Roanoke to Norfolk.—The line follows down the valley of the Roanoke River out of Roanoke for ten miles and then cuts across through the country and through the main range of the Blue Ridge Mountains for nearly 30 miles where it joins the river valley again. In the first five miles out of Roanoke the river is paralleled quite closely on the left-hand bank at about water grade. The grade then rises for ten and one-half miles with a maximum rate of 0.2 per cent., compensated, to a summit in the mountains. To hold to the established maximum grade and to secure a good alignment the first five miles has required construction that is particularly difficult, although the total yardage per mile is not very great. The side of the valley is continually broken by the deep valleys of small mountain streams flowing



Compressor Plant at Allegheny Summit Tunnel, and Heading at East Portal of Tunnel.

A double 6-ft. gauge track is laid in the tunnel and over these tracks the skips are drawn to and from the portal by mules. The cableway lifts the skip and its truck and carries it out to the waste bank, where the skip is dumped by an aerial dumping device controlled by the hoisting engineer.

An approach cut 800 ft. long and containing 33,000 cu. yd. of rock has been made at the east portal of the tunnel by a Model 20 Marion steam shovel. This material and that from the heading has been carried out to make a fill in the next mile.

The material encountered in the four headings of this tunnel has been about the same and consists of a dense sandstone, resembling slate. It lies differently in the various headings, however, and in places has been worked with some difficulty. All of the headings have thus far been timbered. The headings being driven from the east and west portals have been carried forward by first taking out a small center heading and then blowing in the sides. The headings leading from the shaft have been driven partly in this manner, and partly by first carrying forward a drift on each side until the wall plate timbers could be placed, and then blowing out the center.

Allegheny Tunnel to Roanoke.—From this tun-

er portions of it are being handled with steam shovels.

A large yard, laid out to handle economically long, heavy trains, is being built in Roanoke. The portion of this yard that will serve through traffic will be about three-quarters of a mile in length and will have from four to seventeen tracks. A yard for local traffic, an engine house and a light repair yard will also be built at this point. The through traffic yard that has been laid out here calls attention to the location layout of stations and passing tracks between Princeton and Norfolk. Stations and passing tracks are located as nearly as possible 6.5 miles apart and practically without reference to the location of centers of population. In fact, Roanoke is the only city of any size on the two railroads between Norfolk and Deepwater, the latter being a village, and no attempt has been made to reach centers of population, the controlling factor of location being the topography of the country through which the easiest grades and most direct alignment between the coal fields and tidewater could be secured. At the stations the standard arrangement is a passing track, 4,000 ft. long and a house track 1,400 ft. long. The main line grades are generally reduced to one-half their regular rate at passing tracks. With these long passing tracks placed at such frequent in-

into the river. Between these valleys are high, narrow hills that extend out to the water's edge with practically their full height. Until the line leaves the river valley, five miles from the start of the rise, the construction work consists largely of excavating side hill cuts in the short, steep rocky hills which extend out into the river. The grade is from 75 to 100 ft. above the water in this distance, and where the line closely parallels the stream bench cuts are made and are widened out enough to carry the tracks. A tunnel, 763 ft. long, with heavy approach cuts in rock has to be driven about two miles before the line leaves the river valley. About a mile east of this tunnel the river makes a detour to one side which has been cut off by making a 70,000 cu. yd. cut through the hill around which the river flows.

From the point where the line leaves the river valley until it joins the valley again, nearly 30 miles beyond, the river makes a long bend to the south from its general east and west direction. The construction of the line across the country saves about 23 miles of distance and a large amount of curvature over what would have been involved if the line had been continued down the river valley. The adopted line, however, even with the great saving in distance as compared with a river route, will cost in the neighborhood of \$1,000,000 more than the latter route and re-

quires some very heavy grading work through scattered hills and spurs of the main range of the Blue Ridge Mountains.

Between the point where the line leaves the river valley at a height of about 150 ft. above the water and the summit of the grade, in a distance of about 6 miles, it is following across the country well up above the valleys. The grading largely consists of short cuts through the tops of the hills with fills and occasional high steel viaducts over the valleys. It is mostly in rock, and runs quite heavy, the maximum being 130,000 cu. yd. to the mile. Most of this work is being handled with carts and cars, although two traction steam shovels are installed. The first of the viaducts of any magnitude spans the valley of Beaver Dam Creek; it is 725 ft. long and has a maximum height of 90 ft. Another of these viaducts is two miles from the one just mentioned and spans Kate's Creek. This structure is 870 ft. long and has a maximum height of 110 ft. Both of these viaducts have 30-ft. towers and 60-ft. spans and are built with their tower legs on concrete pedestals.

A mile beyond the Kate's Creek viaduct is a cut near the summit of the grade which contains 140,000 cu. yd., and 2 miles beyond this cut is the summit from which the grade is continuously falling to the east with a maximum rate of 0.6 per cent., compensated. At the summit a tunnel, 1,000 ft. long and with an approach cut of 51,600 yd. in rock to the west portal and one of 43,600 yd. to reach the east portal, is being driven.



Combination Cableway Skip and Tunnel Car.



Views Showing 160,000-yd. Fill over Trough Run and 260,000-yd. Cut at Moneta, 50 ft. above Grade.

These two cuts are just being completed and were made with two 70-ton Atlantic steam shovels working in connection with narrow-gauge dump cars handled by light locomotives. The approach cut at the west is being hauled about three-quarters of a mile to make part of a 117,400-yd. fill, and the material from that end of the tunnel will be hauled to the same fill. The material from the east approach cut is being hauled out to the east to help make a 114,300-yd. fill that is required in a length of 1,200 ft. A Sullivan air compressor with a capacity of 1,000 cu. ft. per minute has been installed in a power house on the summit of the hill through which the tunnel is being driven. It supplies air under a pressure of 120 lb. through a pipe line 3,800 ft. long to the drills used in the two approach cuts and will also supply air to the drills in the tunnel.

The grading runs about 70,000 cu. yd. to the mile for two miles beyond the big fill east of this tunnel. The largest amount of grading in single pieces of work on the entire line is then being carried on in the next two miles. The first of these in order is a fill 85 ft. high across the valley of Trough Run which contains 160,000 cu. yd. of material. Less than a mile beyond this fill is a cut near the Moneta station from which 260,000 cu. yd. of earth and rock are being removed in a distance of 4,000 ft. A 45-ton Vulcan steam shovel is at work in this cut and is

served by trains of 2½-yd. narrow-gauge dump cars hauled by light locomotives. Thus far the material has been hauled out to the west and used in the 160,000-yd. fill. The latter was made in two lifts; first a pole trestle 45 ft. high was built across the valley and a track from the shovel in the cut laid around the side of the hill to it. After the fill had been brought up to the top of this trestle a second trestle was built on the first and a track run out on it from grade to complete the fill. The remainder of the material from the 260,000-yd. cut will be hauled out to the east and used in fills on that side of the hill. The contract for the construction of the 20 miles between Roanoke and the 160,000-yd. fill just mentioned was awarded to the D. A. Langhorne Co. The next 32 miles are being constructed by Lane Bros. Co.

(To be Continued.)

AN ABSURD DEVELOPMENT OF TRADE UNIONISM is the controversy that has arisen in New York between the plumbers and steam-fitters as to whose class the installation of vacuum cleaning system piping in buildings belongs. The plumbers lay claim to this work for the reason that connection is made from these systems to the sewers, while the steam fitters maintain that the system is analogous to compressed air piping systems and properly belongs to them.

Holding Power of Railroad Spikes.

The rapid increase both in amount of railroad traffic and weight of rolling stock and the growing necessity of using soft woods for ties have made the determination of a proper fastening between rail and tie a matter of immediate importance, and attention is therefore drawn to a bulletin prepared by Mr. R. I. Webber and recently published by the University of Illinois Engineering Experiment Station, describing a series of experiments conducted to determine the holding power of various types of railroad spikes under varying conditions. Two distinct lines of experiment were undertaken, the object in one case being to determine the resistance to direct pull, and in the other the resistance to lateral thrust. The ties were supplied from the stock piles of various railroads and tie treating plants and no attempt was made to trace their history further back than the place of growth and the date of treatment. Treated ties were used in a majority of the experiments, creosote, zinc-creosote and zinc-tannin being the kinds of treatment represented. A large percentage of the ties were oak, but elm, beech, ash, loblolly pine, sweet gum, poplar and chestnut ties were also used. Both screw spikes and the ordinary kind were tested.

Resistance to Direct Pull.—These experiments were made with a Riehle 100,000-lb. testing machine, the tie being placed on top of the upper head of the machine, spike downward. The

pulling device for ordinary spikes was a Verona spike-puller threaded into a piece of steel gripped by the lower jaws of the machine. A similar but specially designed device was used for the screw spikes. A scale graduated to 1/16 in. was set so that the movement of the lower head could be measured directly. A load of 500 lb. was applied, to insure the ties having a good bearing, before any readings were taken. The machine was geared to move at the rate of 5/8 in. per minute and as each spike was withdrawn observations were taken when the lower head of the machine had moved through 1/8, 1/4, 1/2 and 3/4 in. and when the maximum resistance was developed. In testing the screw spikes a reading was also taken when the spike had been pulled 1 in.

In investigating the holding power of ordinary spikes they were driven to a depth of 5 in. by an experienced track foreman, care being taken to avoid knots or cracks. Whole ties were used to insure freedom from splitting and three spikes, alike in size and shape, were driven into each tie. It is thought that a pull of 1/4 in. gives results of more value for purposes of comparison than the results for greater or less distances because a withdrawal of more than 1/4 in. should not occur in practice. The maximum resistance did not occur until the spike had been withdrawn 3/16 to 3/8 in. When a spike is driven the wood fibers are bent downward and pressed

outward. As it is withdrawn the friction tends to draw the fibers back to their original position and causes them to crowd laterally against the spike and upward toward the surface. If the structure of the wood is loose there is considerable cellular space for the displaced fibers to occupy and the maximum resistance is low and quickly attained, but when the wood is more dense the reverse is true. The spikes varied somewhat in size and in shape of point. The length was $5\frac{1}{2}$ or 6 in., but as all the ordinary spikes were driven to a depth of 5 in. the difference in length was of no importance. In cross-section they were $\frac{5}{8}$, $19/32$, and $9/16$ in. square. A series of special tests with square rods showed an irregular increase in holding power as the size increased, but the slight differences in the cross-sections of the spikes produced no consistent differences in results. The average values derived from a number of tests and a comparison between treated and untreated ties is shown in the table. The increased hold-

RELATIVE HOLDING POWER IN POUNDS IN TREATED AND UNTREATED TIES.

Wood.	No. ties.	No spikes.	Condition of tie.	(Resistance to pull)		
				$\frac{5}{8}$ -in. pull.	$\frac{9}{16}$ -in. pull.	Max. resistance.
Elm	27	15	Untreated	2310	5390	7290
			Treated	2590	5940	7500
Beech	1	9	Untreated	2240	3790	8180
			Treated	2950	6190	8000
Loblolly pine..	1	6	Untreated	2920	3190	3630
			Treated	2920	3730	4310
Red oak	3	15	Untreated	..	..	6460
	4	21	Treated	..	..	7730

ing power of the spikes in treated ties is attributed to two causes: (1) The presence of the preservative in the cells which reduces the space into which the fibers can crowd as the spike is withdrawn; and, (2) the hardening of the fibers by steaming, preparatory to treatment, which makes them less pliable.

Experiments were made to determine the effect on the holding power of ordinary spikes, of different preservatives in the wood, various depths of penetration, different forms of spike-point, boring holes as for drift bolts and re-driving the spike. The conclusions drawn are given later in the summary of results.

A series of tests, conducted in the same manner as those with ordinary spikes, was made to determine the holding power of screw spikes without linings. The spikes varied in length from 5 to $5\frac{1}{2}$ in. The diameter of the core was $21/32$ or $11/16$ in., the projection of the thread $\frac{3}{8}$ or $3/16$ in., and the pitch uniformly $\frac{1}{2}$ in. A $11/16$ -in. hole was bored for all these spikes, and the depth of insertion was $4\frac{1}{2}$, $4\frac{3}{4}$ or 5 in. The shank or threaded portion of the spike was usually $\frac{7}{8}$ of an inch in diameter, and approximately one inch of the upper portion of the core tapered from the diameter of the core to that of the shank. The hole bored for the spike was not reamed, and the result was a tight fit between the wood and the spike. This tight contact is gained in practice by the spike head bearing against the base of the rail. The spike was driven with a wrench, the thread cutting its own path. The number of screw spikes obtainable was not sufficient to make as long a series of tests as with the ordinary spikes.

Comparing the screw spike with the ordinary variety the holding power of the former is always the greater though the relation between the two varies in different timbers. For a pull of $\frac{3}{4}$ of an inch in the hardwoods the holding power of the screw spike is from 167 to 221 per cent. of that of the ordinary spike, and in the soft woods the range is from 117 to 258 per cent.; or the average gain in the hardwoods is 76 per cent., and in the soft woods 98 per cent. The resistances in the several timbers for the $\frac{3}{8}$ in. pull with the screw spike are in eight out of eleven instances nearly the same as, or greater

than, the resistances for the $\frac{1}{4}$ -in. pull with the ordinary spike. This signifies that the screw spike is about twice as efficient as the ordinary spike for a pull of $\frac{1}{4}$ of an inch or less.

The average resistance of the screw spike in pounds per inch of penetration seems in general to increase slightly as the depth of penetration increases.

A few experiments were made with screw spikes and helical linings. On account of the small number of linings obtainable the tests were limited. The linings were made by Mr. J. Thiollier, of Paris, France, and are of the class which he calls P. M. or small sized linings. They were 4 in. long with a $\frac{1}{2}$ -in. pitch. The total diameter was $1\frac{15}{16}$ in., the inside diameter a little more than $1\frac{1}{16}$ in., and the thickness and width of the metal band $\frac{1}{8}$ and $\frac{3}{4}$ in., respectively. These linings were designed to be used with the screw spike of the French Eastern Railway and were tested with this spike only. A hole having the same diameter as the core of the spike was bored in the tie; the hole was tapped, and the lining inserted by means of special tools designed for the purpose; the spike was inserted in the usual manner.

The results of the tests show that in hard woods the resistances for $\frac{3}{8}$ -in. pull are usually greater for the spike and lining than for the naked screw spike, but for pulls greater than $\frac{1}{2}$ in. the reverse is true. In soft woods the spike and lining gave greater resistances than the naked screw spike except in sweet gum. The lower resistance in the hard woods is accounted for by the fact that the spike begins to move before the lining, and the fibers, being hard, are bent slightly upward so that the bearing surfaces of the wood and the spike are only partially in contact. Moreover, the fibers probably slip over the rounded edge of the lining, which tends to lower the resistance. In the soft woods the fibers mash together more as the spike is pulled out, consequently the bearing surfaces of the wood and the spike have full contact and the resistance is greater than with the naked screw spike. The principal claims for the P. M. lining are that it can be placed without removing either rail or tie and that it is an advantageous substitute for the square wooden dowel sometimes used. It is doubtful, however, if this device is of value even as a repair measure for it extends only about $\frac{1}{8}$ in. beyond the thread of the spike and when the spike has been pulled even a small distance the adjacent wood is badly damaged, so that the wood which remains after the hole is tapped for the lining can offer but slight resistance. Moreover, it is not certain that the extreme fibers reached by the lining are not somewhat affected, hence it would be better to ream the hole, cutting out all damaged wood and to introduce a threaded hard wood dowel or a larger lining.

Resistance to Lateral Displacement.—The rail-spike is subjected not only to a direct pull by the undulation of the rail but to a horizontal thrust which is especially severe on curves. To determine the resistance to lateral displacement developed by various forms of spikes a series of tests was made in which the lateral thrust was produced by the blows of a heavy hammer consisting of a cast iron weight suspended by a wooden rod from the joists of the floor above.

The weight of the hammer was 100 lb. and the distance through which it was allowed to fall was $1\frac{1}{2}$ ft., so the impact for each blow was 150 ft.-lb. The hammer delivered its blow on the end of a tool-steel bar which projected beyond the end of the tie, the other end being shaped to fit under the head of the spike. Nine-sixteenth in. and $\frac{5}{8}$ -in. ordinary spikes and screw spikes were used and each one was subjected to five blows, the displacement produced by each blow being carefully measured. Usually four or five

spikes of each kind were tested, but when there was much lack of uniformity in the results a larger number were used.

All of the spikes were bent to a curve, the central point of which was about $1\frac{1}{2}$ in. below the surface of the tie. The ordinary spikes were pulled from the tie a short distance, but the thread of the screw spikes gripped the wood so as to prevent their being pulled out even a perceptible amount. The total deflection of the $9/16$ -in. spikes was usually sufficient to allow a rail to clear the head of the spike if it were overturned. The corresponding movement of the $\frac{5}{8}$ -in. spikes was usually sufficient to allow a like clearance, although it was considerably more than would be allowed in practice. The first blow is of more importance than the succeeding blows in testing the efficiency of a spike. While the distances through which the different sized spikes were deflected by the first blow differ but a small amount, this difference is sufficient to show that the deflection is less for the $\frac{5}{8}$ -in. spikes than for the $9/16$ -in.

In oak, ash, elm and beech ties the average total deflection of screw spikes was $\frac{1}{2}$ in. or 0.15 and 0.25 in. less than the $\frac{5}{8}$ and $9/16$ -in. ordinary spikes, respectively. In poplar, chestnut, sweet gum and loblolly pine ties the average total deflection of the screw spikes was about the same as those $\frac{5}{8}$ -in. square and 0.25 in. less than the $9/16$ -in. The ordinary spike was usually displaced more than the screw spike by each blow. This should be expected since the common spike was smaller in cross section than the screw spike, and also since the latter had better bond with the wood. While the use of the screw spike is recommended to the American railroads, it is thought that the practice of Bavarian railroads could be followed to advantage. These roads have adopted the use of the screw spike on the gage side of the rail to resist overturning, but use two square spikes on the outside to resist lateral movement. This practice has given very satisfactory results.

The conclusions which Mr. Webber draws from the tests are summarized as follows: (1) The maximum resistance to direct pull varies from 6,000 to 14,000 lb. for screw spikes, from 3,000 to 8,000 lb. for ordinary spikes in untreated timbers, and from 4,000 to 9,000 lb. for ordinary spikes in treated timbers. (2) The pull required to withdraw ordinary spikes $\frac{3}{8}$ in. varies from 2,000 to 3,500 lb. for untreated, and from 2,500 to 3,500 lb. for treated timbers. (3) The pull required to withdraw ordinary spikes $\frac{1}{4}$ in. varies from 3,000 to 5,400 lb., and from 3,800 to 5,900 lb. (4) Timbers having loose fiber structures have lower resistances to direct pull than more compact timbers. (5) The amount of withdrawal which must occur for ordinary spikes to develop the maximum resistance is less for soft than hard woods. (6) Spikes in treated timber offer a greater resistance to direct pull than in untreated timbers, and the difference between the two is greater for soft than for hard woods. (7) The difference in resistance for the different size spikes in use is very small. (8) The resistance of ordinary spikes to direct pull varies directly as the depth of penetration, neglecting the tapering point. (9) Blunt-pointed and bevel-pointed spikes have a slightly greater resistance to direct pull than chisel-pointed. (10) For withdrawals less than $\frac{1}{4}$ in. ordinary spikes driven into bored holes have a little greater resistance than those driven in the ordinary way. (11) The resistance for re-driven spikes is 60 to 80 per cent. of newly driven. (12) The efficiency of screw spikes to resist withdrawal is nearly twice as great as that of common spikes. (13) The resistance of $\frac{5}{8}$ -in. spikes to lateral displacement is slightly greater than that of $9/16$ in. (14) Screw spikes are more efficient than ordinary spikes in resisting lateral displacement.

The Extension of the Chicago, Milwaukee & St. Paul Ry. to the Pacific Coast.

The decision of the Chicago, Milwaukee & St. Paul Ry. to extend its lines to the Pacific Coast was officially announced about a year ago. Since that time the location surveys have been completed, right-of-way has been secured, contracts have been awarded for considerable parts of the construction, and terminal sites in Seattle and Tacoma, Wash., have been purchased. An official statement made public last week announces that the eastern 731 miles of the extension, reaching to Butte, Mont., will be finished by Jan. 1, 1908, and that the entire line will be completed to the coast a year later.

The extension commences at Glenham in the northern central part of South Dakota, 8 miles east of the present crossing of the Missouri River at Everts, and 767 miles from Chicago. The line will cross the Missouri River 12 miles from Glenham and about the same distance north of Everts. The bridge at this crossing will consist of three 425-ft. spans, with a steel trestle approach, 1,300 ft. long at the east end and one 125 ft. long at the west end. The grade of the track will be about 60 ft. above high water at the crossing. The piers will be of concrete faced with granite, and the excavations for their footings are to be made by the pneumatic process. The super-structure of this bridge will contain 7,500,000 lb. of steel, the contract for which has been awarded to the Pennsylvania Steel Co. The construction of the piers and the erection of the super-structure will be done by the regular forces of the bridge department of the railroad.

From the Missouri River the line follows the valley of Oak Creek and its tributaries for about 40 miles, and then practically parallels the state line between North and South Dakota on the plateau between the Cannonball and Grand Rivers for about 50 miles, advantage being taken of natural drainage from this plateau to the crossing of the Little Missouri River. The first 80 miles west of the Missouri River is entirely within the Standing Rock Indian reservation, and the line enters North Dakota as it emerges from the reservation. The country is a rolling prairie between the valleys of the Missouri and Little Missouri Rivers, and, excepting one cañon at the head of Hay Creek and the east side of the valley of the Little Missouri River, affords no engineering difficulties.

From the Little Missouri River to the Yellowstone River the line follows Corral, Sandstone and O'Fallon Creeks. The extension crosses the state line between North Dakota and Montana about 8 miles west of the Little Missouri River. The line follows the Yellowstone River from a point 4 miles east of Terry, Mont., where there will be an overhead crossing of the Northern Pacific Ry., to Forsyth, Mont., a distance of about 90 miles. The river will be crossed three times in this distance, the first crossing occurring about 5 miles west of Terry, the second about 11 miles east of Miles City, and the third about 6 miles west of Miles City. Each of these bridges will consist of four spans with a total length of 1,100 ft. It is probable that division terminals will be established at Miles City.

Leaving the valley of the Yellowstone at Forsyth, the line follows Porcupine and Home Creeks to the Musselshell Valley, which valley is followed for a distance of about 100 miles to Harlowton, where connection will be made with the Montana R. R., an independent line, 163 miles long, 95 miles of which will be included in the extension. To adapt this line to the grades of the extension, it will be radically revised, much curvature and many heavy grades being eliminated. At Summit station, about 40 miles west of

Harlowton, the Belt Mountains are crossed, the maximum elevation being 5,800 ft.

At Lombard the line crosses the Northern Pacific Ry. overhead, and the Missouri River by a six-span bridge, 600 ft. in length, and then follows the Missouri and Jefferson Rivers to the east slope of the Continental Divide, near Whitehall. Between Whitehall and Butte the main range of the Rocky Mountains is crossed through Pipestone Pass at a maximum elevation of 6,350 ft. Two tunnels, 2,450 and 1,280 ft. in length, and three steel trestles from 100 to 160 ft. in height, and from 400 to 600 ft. in length, are features which indicate the nature of the construction on this portion of the line.

From Butte, at the foot of the west slope of the divide, the line follows the Deer Lodge, Hell Gate, Missoula and St. Regis Rivers to a point about 4 miles west of Saltese, Mont., where the ascent of the Bitter Root Mountains begins. St. Paul pass, the summit in these mountains, is reached at an elevation of 4,200 ft., and a tunnel 8,500 ft. in length is necessary in crossing this range. The line follows the drainage of the St. Joe River to within a few miles of its mouth from this pass, and crosses the Idaho-Washington state line just east of Tekoa, Wash. The Columbia River is crossed by a bridge of fifteen spans having a total length of 2,750 ft., exclusive of steel trestle approaches 1,000 ft. long at each end. The super-structure of this bridge will contain 40,000 tons of steel, the spans and trestles being carried by concrete piers and abutments. The grade line is 80 ft. above low water at this crossing.

At Johnson Creek summit, about 20 miles west of the Columbia River, a tunnel 3,400 ft. in length will be driven. At Snoqualmie Pass there will eventually be a tunnel about two miles long at a maximum elevation of 2,569 ft., but for the present the operations through the pass will be by a surface line at a maximum elevation of 3,010 ft.

At Maple Valley, Wash., connection is made with the Columbia & Puget Sound R. R., over the tracks of which access is obtained to an ample terminal site purchased at Seattle. A new line will be constructed from Black River, at Junction, Wash., to Tacoma, where a large amount of terminal property has also been secured.

undoubtedly based on careful estimates. Although construction methods have been greatly improved, much heavy machinery has been adapted to railroad work and men have become better equipped to handle this class of construction since the pioneer days of transcontinental railroad building, no rate of construction speed approaching the announced time of the completion of the extension has ever been approached, and the outcome will be carefully followed.

The Chicago, Milwaukee & St. Paul Ry. will be the second continuous line between Chicago and the Pacific coast when the extension is completed, the Atcheson, Topeka & Santa Fe Ry. being the only existing continuous line. The new line will have a total length of 2,238 miles between Chicago and Seattle, which is approximately the same as the length of the Great Northern Ry. and its connections between those cities. All other competing lines are from 100 to 250 miles longer. The length of the Chicago, Milwaukee & St. Paul route is based, however, on the length of the extension from Glenham to Seattle being 1,450 miles, which length may be slightly increased or decreased when the final locations of parts of the line in Montana, Idaho and Washington have been made.

Resistance of Wood to Shock.

Little study has been given to the resistance of wood to the action of impact loads, such as result when a locomotive passes over a wooden trestle. The Forest Service has been studying the subject at the timber-testing station at Purdue University, Lafayette, Ind., and finds that wood is more elastic under impact than under gradually applied loads. This would go to show the wisdom of locomotive engineers in taking a weakened trestle at high speed.

Air-dried loblolly pine specimens, both of natural and steamed wood, 2 x 2 in. in cross-section, were tested in bending on a 34-in. span under both impact and static loadings. The moisture content was approximately 13 per cent. of the dry weight, or about the moisture condition of air-dry wood.

The maximum deflection under a gradually applied load was 1.2 in., and the deflection just preceding failure under impact was 1.1 in. There

TESTS OF THE RESISTANCE OF WOOD TO SHOCK.

	Natural wood.		Wood steamed.		Natural wood.		Wood steamed.	
	Static.	Impact.	Static.	Impact.	Static.	Impact.	Static.	Impact.
Number of tests.....	8	8	8	8	7	7	7	7
Annual rings per in.....	7.5	7.5	6.5	7.0	7.5	6.5	7.0	7.5
Per cent. of moisture.....	13.8	13.1	13.4	13.1	12.7	13.3	12.2	13.1
Specific gravity.....	0.558	0.550	0.546	0.537	0.553	0.559	0.571	0.564
Deflection at elastic limit, in.....	0.31	0.67	0.34	0.67	0.36	0.64	0.31	0.66
Fiber stress at elastic limit (lb. per sq. in.).....	6,496	15,018	6,380	13,490	7,250	12,465	6,069	11,563
Modulus of elasticity (1,000 lb. per sq. in.).....	2,061	2,150	1,829	1,894	1,966	1,853	1,943	1,720
Modulus of resilience (in.-lb. per sq. in.).....	1.164	5.88	1.241	5.36	1.495	4.74	1.091	4.51

The wood steam was treated for 4 hours at 20 lb. pressure to give the results in the fourth and fifth columns, and for 4 hours at 30 lb. to give the results in the last two columns.

The line from Glenham to Butte is under contract to McIntosh Brothers, of Milwaukee, Wis. The Bitter Root tunnel and approaches, for two and one-half miles on each side, are being built by Mr. Nelson Bennett, of Tacoma, Wash. The line between the Bitter Root mountains and the coast is under contract to Mr. H. C. Henry, of Seattle. All steel bridges and trestles will be erected by the bridge department of the railroad. Grading is completed and track laid from Glenham to a point about twenty miles west of the Missouri River, the crossing being made on a temporary pile bridge. Much grading has been done in the Yellowstone and Musselshell Valleys, and sub-contracts have been let and forces are at work on the balance of the line.

The official announcement that the 1,450 miles of construction included in the extension, much of it through mountainous sections and all of it involving numerous heavy bridge structures, will be complete in a little more than two years is

is, thus, little difference between the ultimate deflection of wood under the two kinds of loading. But at the elastic limit the average deflection under gradual loading was 0.33 in., while the average deflection under impact loading was 0.66 in. Thus this wood possesses twice the elastic strength under impact that it does under static load. The detailed tests upon which these statements are based are given in the accompanying table.

The wood steamed was treated for 4 hours at 20 lb. pressure to give the results in the fourth and fifth columns, and for 4 hours at 30 lb. to give the results in the last two columns.

A CONCAVE SECTION FOR COUNTRY ROADS has been tried experimentally in England. A drain pipe under the center of the road, provided with inlets and gratings, carried off the surface water, and the choking of this drain was the principal difficulty encountered.

The Boiler House of the Birmingham Railway, Light and Power Co.

The power station of the Birmingham Railway, Light & Power Co. supplies current for the entire electric lighting and railway system of Birmingham, Ala., and its suburbs. The equipment was enlarged from time to time until it consisted of a number of detached structures with many antiquated return tubular boilers and a number of new Babcock & Wilcox boilers provided with Dutch oven grates. In the recent reconstruction of this part of the plant, the Babcock & Wilcox boilers were retained and provision was made for supplementing them by a number of new boilers, arranged with them on opposite sides of a center aisle running through the 400x116-ft. new boiler house, which has brick walls, steel interior columns and steel roof trusses. The boilers are provided with mechanical stokers supplied from a reinforced concrete overhead bunker on the center line of the building, which has a capacity of five tons per lineal foot and will eventually extend from end to end of the building. Ashes

Robins conveyor over the center line of the coal bunker, about 40 ft. above the ground, which extends the full length of the building and is provided with an automatic traveling tripper arranged to deliver the coal at any point of the bunker. The coal is drawn from the bunker to the stoker hoppers by means of vertical swinging chutes provided with duplex cut-off valves to control the supply. It is burned on chain grates of the Green type.

The ashes are discharged from the ash-pits through chutes into steel cars, provided with bails, which run on narrow gauge tracks in the ash tunnels. The cars are hoisted out of the tunnel by means of a "man-trolley" traveling on an I-beam runway suspended from the bottom of the coal bunkers. Switches are provided to enable the ashes to be dumped at various points or into cars on the receiving track.

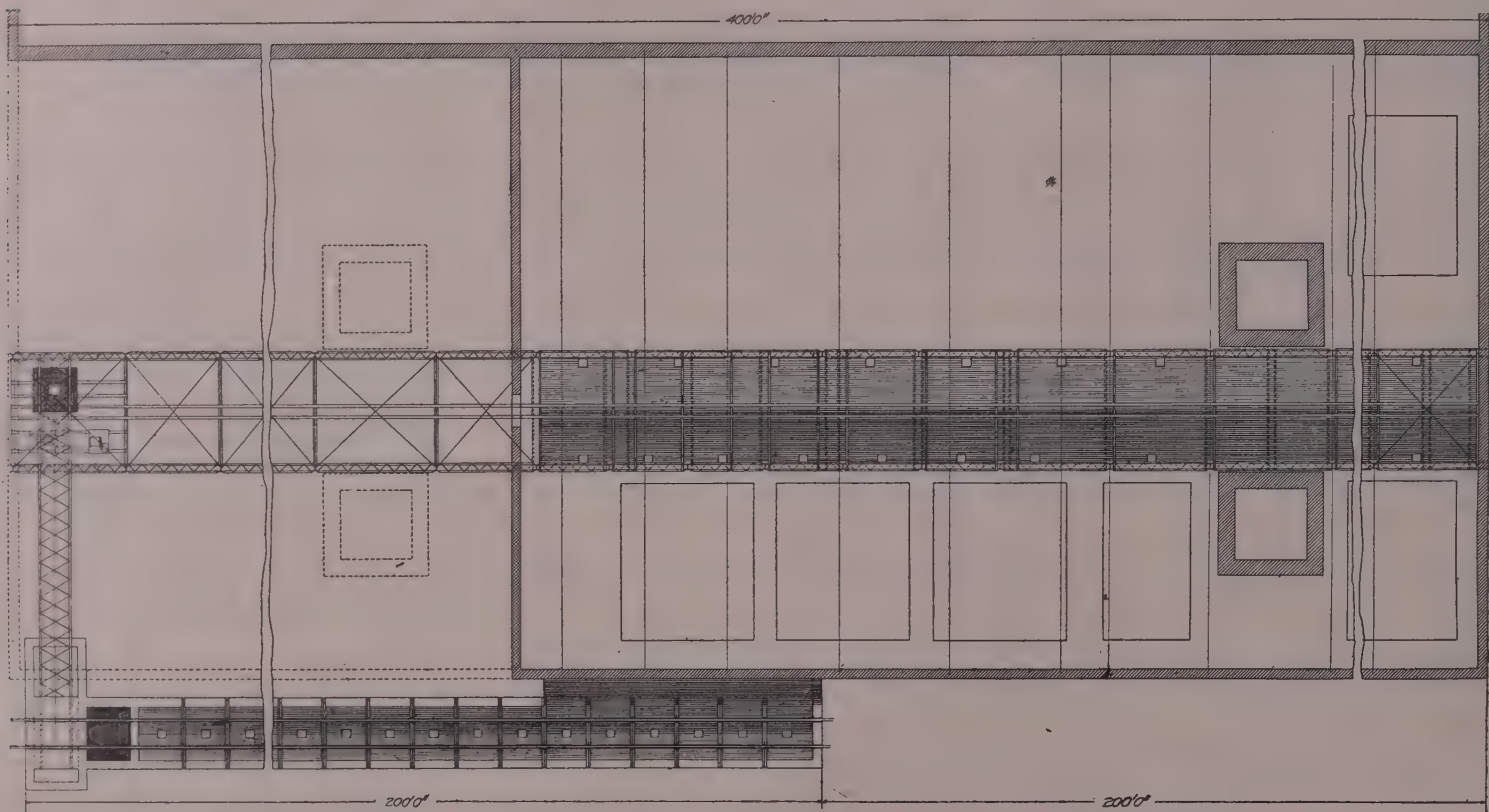
Reserve coal storage is temporarily provided at one end of the building in the space intended for future extensions to the present boiler plant. Here the coal can be automatically dumped on the ground by the traveling tripper of the belt con-

slabs have a comparatively short span and possess ample strength for the moderate loads they sustain. The lining of the ash tunnels and the receiving trench is concrete.

The coal handling plant, bunkers, building, etc., were designed and constructed by the Scofield Company, Philadelphia. One-half of the plant was constructed at first and the entire plant is now being completed. The work has been executed without interrupting the operation of the old plant. Messrs. Ford, Bacon & Davis, New York, are the consulting engineers for the reconstruction of the system.

Concrete Pipe Culverts.

During the past summer an investigation of concrete pipe culverts was made by Mr. O. P. Chamberlain. A number of pipes were built with an inside diameter of 4 ft. and 6-in. walls, resembling in shape large drain tile, having neither bell nor spigot. The concrete was a 1:3½:3½ mixture of Portland cement, limestone screen-



Sectional Elevation of the Boiler House of the Birmingham Railway, Light and Power Co.

are delivered from the furnaces to cars in a pair of 5x7-ft. tunnels parallel with the axis of the building.

All coal is received by rail on a siding about 200 ft. long, parallel with one side of the building, where the cars are dumped into a V-shaped reinforced concrete hopper in a trench about 9 ft. deep and 10 ft. wide. The hopper is provided with cut-off valves at the bottom, discharging the coal on a 30-in. electrically driven Robins belt conveyor with continuous guards, which travels the full length of the trench and delivers the fuel into a hopper provided with a valve for loading a two-ton steel skip bucket of the C. W. Hunt guide elevator type. The bucket is hoisted about 80 ft. on an inclined track to the top of the boiler house, where its contents are automatically dumped into an elevator hopper feeding to motor-driven coal crackers of the Hunt type. The arrangement of bucket hoist is similar to that for charging a blast furnace and the hoisting is done by an electric hoister controlled from the tower at the end of the coal bunker.

The crackers deliver the coal to an 18-in.

veyor, as shown in one of the accompanying sections. As this supply is intended only for reserve no provision is made for rehandling the coal, but it can be very easily hauled to the receiving pit and redelivered to the bunker in the regular way.

A large advantage is claimed for the coal receiving apparatus on account of the great length of the receiving trench, which enables a number of cars to be rapidly unloaded at once and minimizes switching charges. The hoisting, conveying and distributing apparatus requires the services of only two men, one for the skip and one for the upper conveyor when operating continuously, and a third man is necessary at the receiving pit. With the intermittent operation which suffices at present it is possible to get along with two men.

The coal bunker is novel in that the reinforced concrete side walls act as girders proportioned to carry the entire weight of the bunker and contents from column to column. The steel girts serve only to hold the concrete during construction and the transverse walls act as ties to take up the horizontal thrust. The inclined bottom

ings, and crushed limestone which passed a ¾-in. and refused a ½-in. ring. Each pipe was 4 ft. long. The inside and outside forms were of the ordinary wooden tank type. The inner form had one wedge-shaped loose stave, which was withdrawn after the concrete had set 24 hours, allowing the form to collapse. The outer form was in two semi-cylindrical sections, having heavy semi-circular iron hoops on the outside with loops in their ends. When the forms were in position, the loops of one section came directly above those of the other and iron pins slipped through the loops fastened the two sections of the form together. After the concrete had set the pins were withdrawn and the forms removed.

The pipes were built near a derrick with which they were loaded on flat cars for transportation. At the culvert site they were unloaded and put in place by an ordinary section gang, no other appliances than skids being used to remove them from the cars. As each 4-ft. section of 48-in. pipe weighs about 2 tons it was not deemed advisable to build sections longer than 4 ft. to be handled by hand, but where a derrick car is

available there is no reason why they should not be built in 6 or 8-ft. sections. All work except building the forms was done by common laborers, and the cost of the pipes under these conditions was \$2.50 per lineal foot or \$9.62 per cubic yard. This high cost was due, in part, to the small scale on which the work was carried on, and it should be possible to manufacture these pipes in quantity for \$7 per cubic yard, or \$1.83 per lineal foot, including the cost of forms.

These 4-ft. pipes have been placed in low embankments where their tops are only 18 in. below the lower sides of the cross ties. They were laid in shallow ditches which had been made to conform to the shape of the pipe as well as could be with picks and shovels. The back and top filling of the earth embankment was thoroughly tamped. Thus far they have given satisfactory service under heavy freight traffic, but they have not been in use long enough to warrant pro-

Notes on the Battery Tunnel, New York.

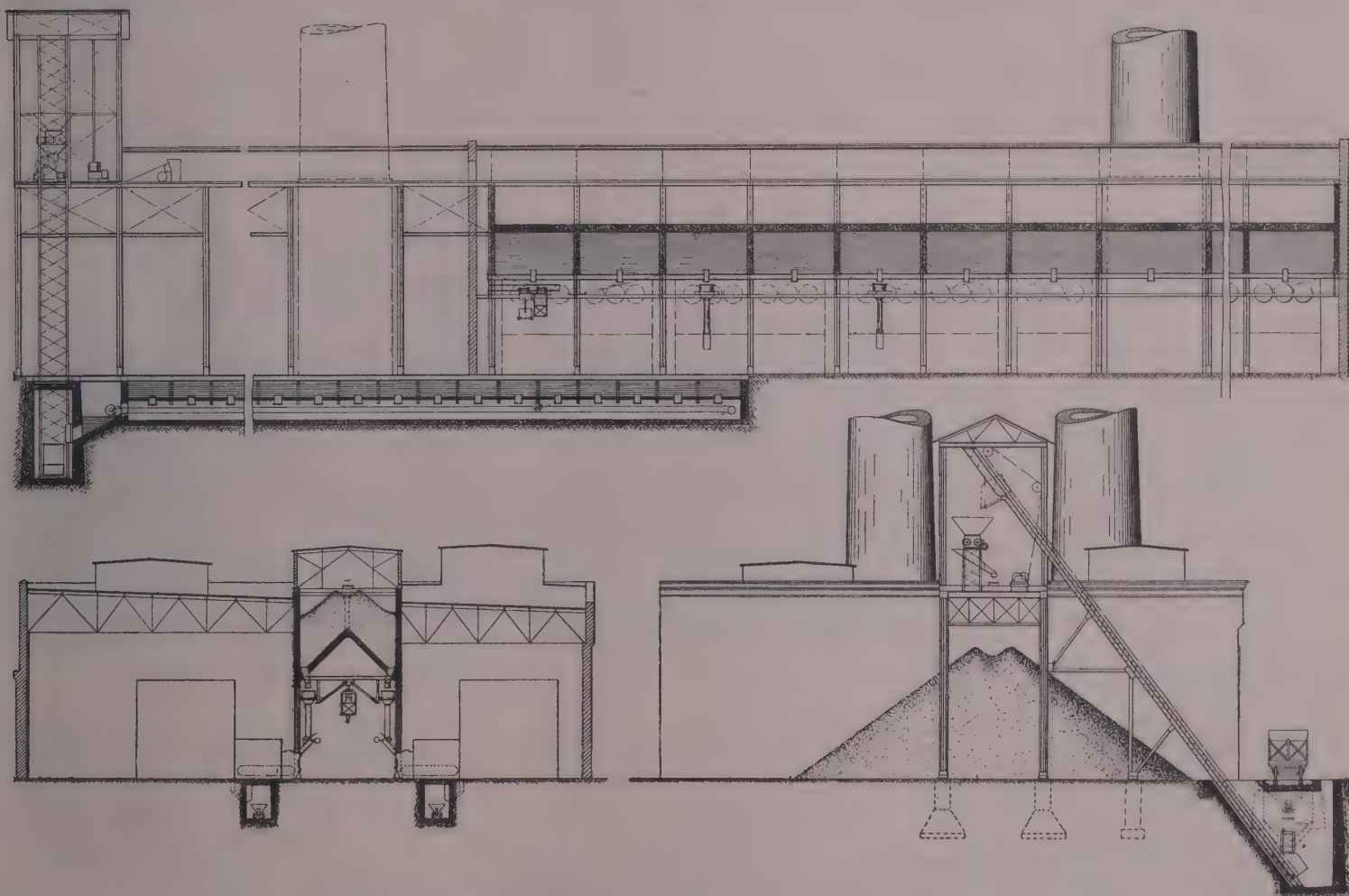
The construction of the twin tubes in the Battery tunnel under the East River has progressed so far that the headings of the north line were connected by a 6-in. pipe as noted in last week's issue, and the shields met accurately on Dec. 14. The preliminary connection through a pipe was to afford opportunity for correcting any deviation which might have occurred in the alignment of the shields, but this was found to be already so good that very slight changes were required, a result that is especially gratifying to the engineers and contractors in view of the fact that the headings were driven on combined vertical and horizontal curves, and through very soft material where it was extremely difficult to prevent settlement.

The 80-ft. pipe connecting the headings was

to flee precipitately, thinking that the river was bursting in on them. Most of the remaining distance to be driven on the south tube is through soft material, and it is expected that at the present rate of progress the headings are likely to meet not later than February.

It is interesting to compare the preliminary connection of these headings through the 6-in. longitudinal pipe with the method used for checking the alignment of the tubes in the Pennsylvania R. R. tunnels under the North River. Here the heading of one line passed beyond both headings of the other line before the latter were connected and horizontal transverse communication was made between the parallel tubes by similar pipes affording an opportunity to check their alignment before the shields met without driving an advance tube to provide direct alignment through the tunnel.

The air pressure in the Battery tunnel is now



Plan of the Boiler House of the Birmingham Railway Light and Power Co.

nouncing them an unqualified success. The cost of transporting and placing concrete pipes is high owing to their excessive weight, but their very low first cost apparently more than offsets this, according to Mr. Chamberlain, even when it is necessary to haul them a considerable distance.

A type of concrete pipe has been designed by Mr. C. H. Cartlidge and adopted by him for extensive use on the Chicago, Burlington & Quincy Ry. It has, in his opinion, passed the experimental stage. This pipe is heavily reinforced, both transversely and longitudinally, with corrugated steel bars, the rings being so placed that the reinforcement is in the outer surface at the sides of the culvert and in the inner surface at the top and bottom. The shape of these pipes is very nearly that of the ordinary cast iron pipes with bell and spigot. They are made with inside diameters of 2, 3 and 4 ft.

about $\frac{1}{4}$ in. in thickness, made in short lengths connected by outside screwed sleeves. Split collars were clamped to it and provided bearings for two hydraulic jacks which were placed on opposite sides and reacted against the shield. The jacks were operated by hydraulic pressure of about 3,000 lb. per square inch furnished by the shield pump, and each jack developed a total force of about 30,000 lb. The driving was facilitated by the use of a hydraulic jet inside the pipe, the nozzle being kept a short distance behind the end of the pipe so as to prevent scour beyond the pipe, which might cause settlement and thus produce a curve in the pipe obstructing the line of vision through it.

When the pipe approached close to the opposite heading, the force of the jet burst through the soft material and excavated a cone-shaped opening into the heading. The rush of mud and water alarmed the workmen and caused them

about 40 lb., which is practically the maximum amount, only 42 lb. having been required for brief intervals. Great care has been exercised in the arrangements for emerging from the air pressure. The air locks are provided with special locked exhaust valves to regulate automatically the escape of the pressure and make it impossible to open the lock in less than 20 minutes when the pressure is 40 lb.

Fresh air is supplied to the men in the lock by a pipe from the tunnel which passes through a heating coil, thus raising the low temperature caused by the expansion, a feature of considerable importance when the men are fatigued and their clothing is saturated with perspiration. It has been recommended that one minute for every pound of pressure above 15 lb. should be allowed for the time in passing out of a lock, but in this case it has been found satisfactory to calculate the time as equal to

the square of one-tenth of the pressure.

In the rectification of grade for the Brooklyn approaches, considerable progress has been made in raising the tunnel roof where the alignment was too much depressed to allow sufficient clearance for the trains at the required grade. After a portion of the invert segments had been replaced by new castings designed to give the tube an elongated vertical diameter, it was found that the method adopted was so satisfactory that it was concluded to extend it to the more difficult operation of replacing the crown segments. The roof plates are disconnected, holes drilled through them and small pieces of the webs are removed making holes just large enough for the insertion of slice bars, with which the sand and the earth are loosened and allowed to flow inwards through the holes, and the plates are forced upward by jacks which push them far enough away to clear the new segments which will be assembled under them to complete the tunnel tube with vertically elongated cross-section. The old segments serve as shields during the operation and remain disconnected outside of the new roof after its completion.

Septic Tanks and Sprinkling Filters at Stratford-on-Avon.

The site of the new sewage-disposal works for Stratford-on-Avon, England, is midway between Stratford and Milcote stations and is 17 acres in area. The character of the subsoil is adapted for sewage works and the configuration of the ground is favorable to the construction of the work in terraces. The area is well removed from any dwellings and close to the river into which the effluent is discharged. The dry-weather sewage flow, including trade waste, is estimated at 250,000 imp. gal. It was found possible to utilize the engine-house and tank sewers of the old disposal works, but owing to the elevation of the new works and the distance the sewage has to be forced the old pumping plant was replaced with more suitable new machinery. The station is now equipped to handle a quantity of sewage and storm water equal to six times the dry-weather flow. The sewage is pumped through about one mile of 15-in. cast-iron main with a rise of about 100 ft. The pipe is carried under the river Avon by an inverted siphon. Iron hatch-boxes are provided at intervals on the main through which it may be inspected, and a washout valve at the river crossing so that the pipes can be emptied for cleaning or repairs.

The sewage is first treated in liquefying tanks and then on bacteria beds operated on the continuous flow system, provision being made for the treatment of filtered effluent on specially prepared land filters. About 10 acres of land are also laid out to receive the filtered effluent in order to meet the requirements of the Local Government Board. The storm sewage is dealt with by means of contact beds. The liquefying tanks and storm-water contact beds are constructed on a high-level terrace, while the second and third terraces are each occupied by four circular sprinkling filters for tank effluent. The land filters are situated at a still lower level. The sewage discharged from the 15-in. main into the small inlet chamber can be readily diverted into any of the liquefying tanks, and the effluent from these can be discharged by gravity on to any of the filters.

The four liquefying tanks are built of brick, the floors being brick on a concrete foundation with a shallow channel down the center to facilitate the removal of sludge. Each tank is 102 x 25 ft. inside with an average depth of 6 ft. The total capacity of the tanks is 375,000 imp. gal. or one and one-half times the dry-weather flow. As it

is desirable to empty the tanks as seldom as possible, a portion of each is cut off by a cross-wall 15 ft. from the inlet end, so that the heavier solids deposited in this compartment can be removed without disturbing the rest of the sewage or affecting the liquefying action. The top of the cross-wall is just below the water level and forms a weir over which the sewage passes in a uniform stream at a low velocity. An area of one acre is reserved for the disposal of sludge from these tanks. It will be buried in trenches. The under-drains from this area discharge onto land at a lower level where the foul water will be treated by irrigation.

The eight circular sprinkling filters have a total area of 5,000 sq. yd., and, being arranged in two equal groups at different elevations, may be used for either single or double filtration. Each filter is 85 ft. in diameter and 5 ft. deep, and is filled with clinker. The distributors used with these filters are of the Cresset revolving type.

An area of about two acres is divided by low earth banks into eight filters, each of which is supplied from a small distributing chamber on the filtered effluent carrier. The filters are under-drained to a depth of 4 ft., and the effluent is carried direct to the river. The irrigation area



Highway Bridge over New York Central R. R. Tracks, New York.

covers about 10 acres of gravelly soil. The filtered effluent can be distributed over this area by pipe carriers and chambers at intervals, and the effluent is carried off by 4-in. tile drains, 4½ ft. deep and 66 ft. apart.

Two 9-in. storm-overflow pipes convey the storm sewage from the inlet chamber of the liquefying tanks to the four contact beds. These are built with brick walls and concrete floors. Each bed is 67 x 50 ft. and 3 ft. 3 in. deep, and is filled with clinker. Both feed and outlet pipes are controlled by automatic siphons. At the end of the contact period the effluent is conveyed directly to the river.

Messrs. Willcox & Raikes were the engineers of the works, which were built by Messrs. Thomas Vale & Sons, Limited. A detailed account of the plant recently appeared in "The Surveyor."

FREIGHT INTERCHANGE between steam and electric railroads has been initiated by the Illinois Central R. R., which has recently filed with the Interstate Commerce Commission a tariff of through rates that includes points on the lines of the Chicago & Milwaukee Electric R.R. This is the first instance of an agreement between a steam and an electric road to interchange freight and make through rates.

The Erection of the Moshulu Parkway Bridge, New York.

A highway bridge across the tracks of the Harlem branch of the New York Central & Hudson River R. R. in the Borough of the Bronx, New York, has two very heavy lattice girders 91 ft. long on centers and carries a roadway 59 ft. 9 in. wide in the clear and two 8-ft. sidewalks. It is skewed 78 deg. and is remarkable for its weight of 250 tons.

It was necessary to erect it without interruption to the heavy traffic on the five railroad tracks which it spanned. These were so located that clearance was only provided between the tracks for two transverse bents of falsework, which were about 35 ft. apart on centers dividing the opening into three nearly equal spaces, which were spanned by nine lines of 20-in. longitudinal I-beams, three in each line, laid directly on the trestle caps. Each set of beams was divided into two panels by wooden transverse struts butting against the beam webs. Each panel was X-braced by wire cables, adjustable by steamboat ratchets, which were looped around the beams and secured by clamps. Short pieces of plank were placed against the beam webs on the outside and wedges driven between them and the loops of the diagonal cables,

developing sufficient friction to prevent the cables from slipping.

The top and bottom chords were received in three lengths; each and all members of the trusses were shipped separately. The ten-car trainload of material was switched from the main track to a long siding passing over the bridge close to the abutment, and each car was delivered to the bridge as required; the steel was hoisted from it by a stiff-leg derrick near the abutment. The erection was accomplished by a movable boom derrick operated by a hoisting engine seated on the ground near the bridge.

In order to maintain the roadway level as low as possible, the bridge has minimum clearance over the tracks and the space thus provided was not sufficient for the erection operations. The interposition of the longitudinal I-beams between the falsework bents and the bridge floor raised the latter above the final position. The bridge was, however, assembled and riveted up complete at the temporary level. After it was finished, jacks were seated under it on the abutments and operated to lift it slightly and release the falsework, which was removed. The jacks were then operated to lower the bridge about 8 in. and deposit it in final position on its permanent seats.

The bridge was built and erected by The American Bridge Co., Mr. A. B. Lueder, assistant engineer in charge.

The Terrace Hydraulic-Fill Dam and Similar Structures.

The recent practical completion of the Terrace dam on the Alamosa River, in Colorado, the highest hydraulic filled dam yet undertaken in this country, makes the paper on "Recent Practice in Hydraulic-Fill Dam Construction," read before the American Society of Civil Engineers, on Dec. 19, by Mr. Jas. D. Schuyler, of particular interest. Mr. Schuyler was connected with the structure as consulting engineer, and gave in his paper the information which follows concerning it. In the issue of *The Engineering Record* of June 9, 1906, there was a paper on the hydraulic-fill dams of the Mexican Light & Power Co., Ltd., with which work Mr. Schuyler was also connected.

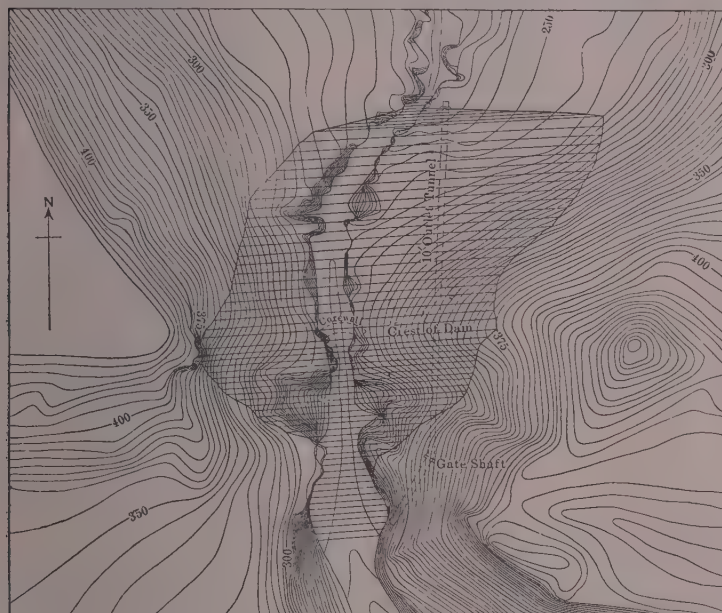
The Terrace dam, which forms a storage reservoir for irrigation purposes, is located at the head of the lower cañon of the Alamosa River, a few miles above the point where the river enters the San Luis Valley. The situation is quite unique, inasmuch as the lower 70 ft. of the dam is in a narrow slit in the bed-rock, from 20 to 60 ft. wide, where the river has cut its way down through a ledge of hard trachyte, forming

with an intermingling of clay. This was sufficiently convenient for sluicing into the dam. On the south side the trachyte has decomposed and disintegrated to a considerable depth, yielding excellent material for hydraulic filling, as the portion that was loose enough to be moved by the hydraulic giant was composed of spalls and splinters of hard rock, intermingled with clay and loam.

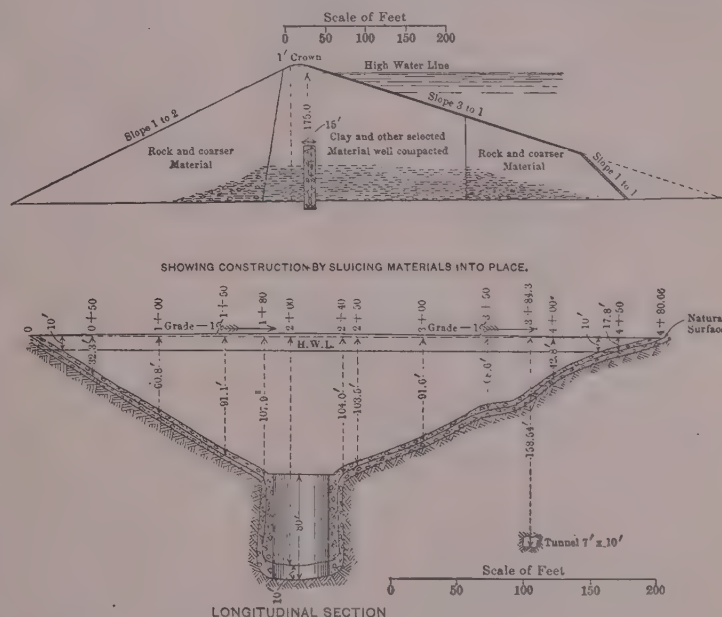
A ditch and flume, 5 miles long, built from a point on the Alamosa River above the reservoir, delivered water about 200 ft. higher than the top of the dam, and the work was carried on by ground-sluicing and hydraulic mining. A tunnel 725 ft. long, 7 ft. high and 10 ft. wide, was excavated for carrying the stream during construction and as an outlet to the reservoir. The outlet gates will be operated from a shaft, 75 ft. deep, sunk through solid rock to the tunnel, at a point about 200 ft. down stream from the crest of the dam. The work was done by contract for 18 cents per cubic yard. The method of building the dam by hydraulic sluicing was first suggested by Mr. T. W. Jaycox, State Engineer of Colorado, and Mr. Schuyler was engaged to report upon the plans. The engineer in charge is Mr. E. W. Case.

cent. for several weeks. The highest of all showed 47.7 per cent., while the lowest was 6.1 per cent. The best week's work was 22,350 cu. yd., deposited in 94.5 hr., or at the rate of 236 cu. yd. per hour. During that week 6.5 cu. ft. of water per second were used, and the ratio of solids to water was 27.2 per cent. The average work performed was 127.3 h.-p., while the recorded electric energy consumed was 176 kw., or 236 h.-p., showing a combined efficiency in pump and motor of 53.9 per cent. (motor 90, pumps, 59.9). The maximum quantity of material moved as a weekly average was 443 cu. yd. per hour; the minimum 47, and the mean 123.

In constructing both the Lake Frances and the Crane Valley dams, also in California, it was found that as the material was distributed it tended to settle in layers. In each instance this stratification was broken up by frequently going over the work in a raft or barge and systematically thrusting long boards as far down into the mud as the weight of a man could force them. Each time the board was withdrawn the silt seemed to enter the hole and the continuity of the strata was destroyed. At the Crane Valley dam this kneading process was deemed so satisfactory that a center wooden core-wall of dou-



Map and Sections of Alamosa Dam of San Luis Valley Irrigation, Land and Power Co.



LONGITUDINAL SECTION

a cañon with vertical side walls. Above this ledge the section across the cañon has a bowl-shaped form like the end of an ellipse. The dam has been projected to the ultimate height of 180 ft. above the river bed in the bottom of the cañon, or about 110 ft. above the valley proper. The length of the dam at the height of 180 ft. is about 500 ft. The crest width, 10 ft. above the water line, or spillway level, is 20 ft.; the upstream slope being 3 on 1 and the downstream 2 on 1. The plan and sections are shown in the accompanying illustrations. In the lower 70 ft. of cañon section, on the center line of the dam, is a concrete core-wall, 15 ft. thick, curved on a radius of 50 ft. Connecting with this wall, and extending up the slopes to the high-water line, are two parallel concrete walls, 25 ft. apart. They are built in trenches cut in the bed-rock, and extend 2 or 3 ft. above the original surface. These walls are designed to intercept seepage along the surface of the bed-rock, and are enveloped in the body of sluiced earth or clay composing the center core.

There are ample evidences that the valley occupied by the reservoir was once a lake formed by glacial action. A gap in the rim of the reservoir, to the north of the dam exhibits a great mass of glacial drift deposited as a lateral moraine, and consisting of sand, gravel and boulders,

Some of the other interesting features of hydraulic-fill dam work, described by Mr. Schuyler are as follows: For the most rapid and efficient service water should be used under a pressure of 100 to 150 lb. per square inch at the nozzle of the monitor, and in a volume of 10 to 15 cu. ft. per second. Instances are mentioned, however, when much smaller quantities of water have been used with reasonable success. On the Lake Frances dam on Dobbins Creek, California, a 6-in. single stage centrifugal pump, direct connected to a 30-h.-p. motor was used for several weeks. This pump delivered 1.76 cu. ft. of water per second under a head of 100 ft., and though it was operated under most disadvantageous conditions, including a scanty supply of water which had to be pumped over and over again, the average ratio of solids deposited to water pumped was about 13 per cent. Later this pump was replaced with a two-stage tandem centrifugal pump which had a capacity of 6 cu. ft. per second under a pressure of 120 lb. per square inch at the pump, was operated by a 350-h.-p. motor and delivered through a line of 20-in. pipe varying from 300 to 700 ft. in length. The weekly percentages of solids carried by the water varied with the conditions encountered. Under favorable conditions the ratio was maintained at from 20 to 30 per cent. and ran from 32 to 38 per

cent. for several weeks. The highest of all showed 47.7 per cent., while the lowest was 6.1 per cent. The best week's work was 22,350 cu. yd., deposited in 94.5 hr., or at the rate of 236 cu. yd. per hour. During that week 6.5 cu. ft. of water per second were used, and the ratio of solids to water was 27.2 per cent. The average work performed was 127.3 h.-p., while the recorded electric energy consumed was 176 kw., or 236 h.-p., showing a combined efficiency in pump and motor of 53.9 per cent. (motor 90, pumps, 59.9). The maximum quantity of material moved as a weekly average was 443 cu. yd. per hour; the minimum 47, and the mean 123.

The spillway of the Lake Frances dam was formed by a slab of concrete 8 in. thick, laid over the surface of the earth, which had been trimmed to an ogee form, the crest being 80 ft. long, with sloping ends and the extreme height of the drop into the water cushion about 16 ft. The slab was reinforced by sheets of expanded metal held in place by $\frac{1}{4}$ -in. wire, embedded in a layer of concrete $\frac{5}{8}$ in. thick, which was allowed to set before the expanded metal was applied. When the sheets had been laid over this first layer and wired down securely, grout was flushed into all the interstices of the metal and a plaster coat of cement and sand in equal parts, 1.5 in. thick, was applied and given a smooth finish.

The dams of the Twin Falls Land & Water Co., on the Snake River, are of the hydraulic-fill and rock-fill types. In constructing them the base of each dam was stripped of surface soil and loose material, and in the center line of the rock-fill a trench, 5 to 6 ft. wide, was excavated in the bed-rock throughout the longitudinal axis and extending up to the level of the

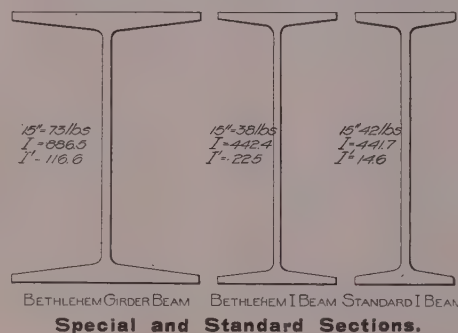
dam top on the sides of the cañon. In this trench a continuous core wall, of double 2-in. plank, was built from the bottom to within 6 ft. of the top, the plank being laid horizontally, breaking joints, and being spiked to 3x6-in. uprights placed on 2-ft. centers. The base of this wooden partition was embedded in well-rammed concrete to a depth of 4 to 6 ft. The loose rock embankment was built up on each side of the fence, which was carried up considerably in advance of the rock. For several feet on either side of the fence the rock was carefully laid by hand to avoid crushing the wood by settlement, and to give a continuous bearing of rock against every square foot of the fence. Outside of this the rock was dumped loosely from a cableway. The function of this wooden core-wall was to permit the earth embankment, built against the rock-fill, to be sluiced in place without flowing out through the voids in the rock. The liquid mud freely entered the voids of the stone and filled them solidly as far as the core wall. As it rose in height some leakage occurred in the partition, but the joints soon swelled, filled with mud, and became tight. The Waialua dam on one of the Hawaiian Islands, has a similar core-wall, but between the two layers of 2-in. plank is a double layer of burlap which was dipped in hot asphalt.

In constructing the hydraulic-fill of this Hawaiian dam the ground-sluicing method was used. Ordinary soil can be washed very readily by water flowing over it, but the volcanic tufa of Hawaii contains a large amount of iron oxide and is difficult to sluice, even when plowed, chiefly because it is totally lacking in any gritty substance to assist erosion. The water had no effect even on plowed ground, and ran over it clear, without washing it away. The method finally adopted was to dig a ditch and turn the water through it at the rate of 8 cu. ft. per second. A traction engine was then used to plow the banks of the ditch 12 ft. back and force them into the water with a V-shaped scraper. This process was continued till the ditch grade was reached, when a new strip was plowed and the ditch shifted over to the bluff bank on either side of its original position. The tufa, while it resembles clay and has an unctuous feeling to the touch, settled in the pond very rapidly and the water flowing away at the drainage outlet was generally clear enough to drink—a fact which Mr. Schuyler regards as very remarkable and which has not been met with elsewhere in his experience.

THE EFFECT OF GOVERNMENT WORKSHOPS on large factories is attracting considerable attention in Great Britain at present, and there is apparently a growing belief that the great private companies able to manufacture munitions of war have not been properly supported. According to "Engineering," the output of cordite in private factories is about 12,000 tons annually, and that of the government factory 2,000 tons, yet the government has given nearly half its orders, to the latter. There are eight private ship-building yards capable of undertaking the largest battleships and only two government dockyards so equipped, yet this year's naval program gives two battleships to the dockyards and but one to the private builders. The cost of production in the government dockyards and factories is stated to be considerably above that in private establishments, but the great defect of extensive government manufacturing is that it is not capable of such quick expansion in time of sudden need as are private industries. This has been thoroughly recognized in Germany and France where the great private works capable of producing munitions of war are encouraged in every way, and government shops are established as minor conveniences and not as competing works.

The New Structural Shapes of the Bethlehem Steel Co.

For some time engineers and architects who have to use structural steel shapes have been interested in the reports that a number of new sections would be rolled at the new Saucon plant of the Bethlehem Steel Co., at South Bethlehem, Pa. It is expected that the new mills will be in operation by next May, and it is now possible to illustrate the new shapes and show something of their range of application as compared with standard sections. The mills will turn out standard beams from 4 to 24 in., standard channels from 4 to 15 in., standard angles up to 8 in., special beams from 8 to 30 in., and special H-columns from 8x8-in. to 16 $\frac{1}{2}$ x 15 $\frac{3}{16}$ approximately. The special shapes are rolled on a Grey universal mill, which enables a thinner web and wider flanges to be produced than is possible by the ordinary method of rolling. In the latter the portion of the roll which acts on the web of a beam has a considerably smaller linear velocity than the portion which produces the upper ends of the flanges and a greater velocity than that which acts on the lower ends of the flanges as the beam passes through the mill. Consequently the web is the only part of the beam actually rolled, and the flanges are produced by crowding or dragging the metal through the flange grooves, which necessarily limits the practical width of the flanges. The larger sizes of shapes so made show a variation in the quality of the material in the webs and flanges, plainly indicating a con-



dition of internal stress due to unequal deformation during the rolling process. In the Grey mill the web is formed by horizontal rolls and the flanges by vertical rolls, and the unfavorable action of deep grooves is thus avoided, all parts of the section being formed by a true rolling process and receiving about the same amount of work during reduction. The Grey structural mill is in no sense an experiment, for one of them has been in use about five years at the Differdingen works of the German-Luxemburgian Mining & Rolling Mill Co. It turns out beams from 10 to 30 in. deep with flanges 10 to 12 in. wide, and these shapes have proved so successful that the entire product of the mill now consists of them. At Differdingen, however, there is but a single mill to produce the shapes from the blooms, while in the Bethlehem plant there are two independent mills, one for roughing, and the other for finishing, as will be mentioned later in more detail.

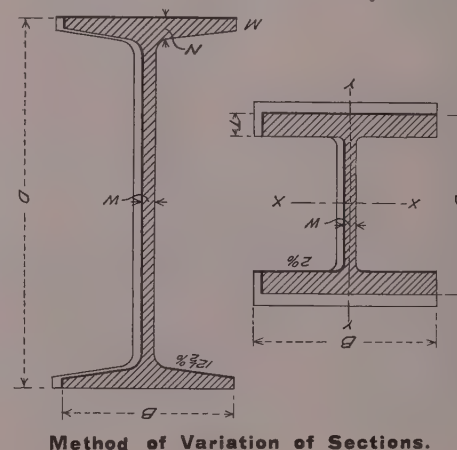
It will be readily seen that the special shapes have advantages for structural work that are not possessed by standard sections. The wide-flange beams can be used instead of riveted members for a variety of purposes, with a saving in weight or in the expense of punching and riveting, and in many cases there will probably be a saving in both items. Three distinct types of special shapes have been adopted, termed special I-beams, girder beams and H or column sections.

The special I-beam sections, 24 in. or less in

depth, have the same section modulus as standard beams of corresponding depth. By reason of the difference in proportion of the shapes, the weight of the special beams is 10 per cent. less than that of the standard beams of the same depth and strength.

The girder beams 24 in. in depth or less, have a section modulus equal to that of two standard beams of minimum weight of the same depth. The weight of the girder beam is 12 $\frac{1}{2}$ per cent. less than the combined weight of the two equivalent standard beams. Heretofore the largest beam rolled in this country has been 24 in. deep, 100 lb. per foot, with a section modulus of 198. Whenever a greater modulus was required a riveted girder was necessary. Bethlehem special I-beams and girder beams run up to a depth of 30 in., a weight of 200 lb. per foot, and a section modulus of 610, or over three times that of the largest standard beam. This means that the field for the use of rolled beams as compared with riveted girders is increased threefold. In order that this may be shown more clearly, Table I, giving the range of properties of special I-beams, and Table 2, giving the properties of special girder beams, have been compiled from the more elaborate tables which will appear later in the company's handbook.

The advantages of such sections are still further illustrated by Table 3, as an example, showing their application as track stringers and for short-



span railroad bridges. The values in the table have been computed according to "Cooper's Specifications for Railroad Bridges," for his E40 loading. All figures are for one rail. The size and weight of the Bethlehem rolled section that is required for the purpose is given for the various spans. As a comparison, the size and weight of the corresponding present standard I-beam that could be employed for the same purpose is also given, so far as standard beams could be used. The economical weight of the Bethlehem beams is apparent from this comparison. Riveted girders would be required on spans greater than 17 ft. in length, unless the more economical rolled Bethlehem beams are used. Bethlehem rolled beams, for all spans under 25 ft. in length, will weigh less than the most economical riveted girder it is possible to design, even when the depth of the latter is unlimited. For spans over 25 ft. in length, the rolled beams will weigh less than riveted girders of equal depth. In every case the Bethlehem rolled section is economical, weight or cost considered, as compared with a standard I-beam or with a riveted girder.

The Bethlehem beams also can be used to advantage for the cross girders or floorbeams of bridges. Where available depth is limited, the rolled girder sections having twice the section modulus of standard beams of equal depth will be found desirable for stringers or cross girders, and prove economical in weight and cost as compared with built-up riveted girders which other-

TABLE 1.—PROPERTIES OF BETHLEHEM SPECIAL I-BEAMS.

Sec. No.	Weight per Foot, Pounds	Dimensions, in Inches.					Increase of Web and Flange for Each lb. Increase of Weight, Inches.	Neutral Axis Perpendicular to Web at Center	Radius of Gyration	Section Modulus.	Coefficient of Strength for Fiber Stress of 16,000 lb.	Add to Coefficient for Each lb. Increase in Weight.	Maximum Safe Shear on Web, Pounds.	Neutral Axis Coincident with Center Line of Web.	Moment of Inertia	Radius of Gyration
		D.	B.	W.	M.	N.										
B 30	120.0	30	10.00	.52	.74	1.333	.010	12.23	351.4	3,748,200	15,690	97,400	149.7	2.11		
B 28	105.0	28	9.60	.48	.68	1.250	.011	11.43	292.1	3,115,700	14,640	83,000	122.6	1.98		
B 26	90.0	26	9.10	.44	.60	1.144	.011	10.71	234.1	2,496,900	13,600	69,700	93.4	1.87		
B 24 a	84.0	24	8.85	.45	.57	1.095	.012	9.82	199.3	2,125,000	12,550	72,600	82.0	1.82		
B 24	72.0	24	8.70	.37	.48	1.001	.012	9.93	174.2	1,858,100	12,550	48,900	67.7	1.79		
B 20 a	72.0	20	8.37	.43	.56	1.056	.015	8.28	146.8	1,565,800	10,460	65,400	67.6	1.78		
B 20	60.0	20	7.58	.375	.48	.930	.015	8.22	119.3	1,272,600	10,460	50,500	43.4	1.57		
B 18	58.5	20	7.55	.35	.48	.930	.015	8.28	117.6	1,254,800	10,460	44,300	43.0	1.58		
B 15 b	52.5	18	7.37	.375	.40	.837	.016	7.35	92.5	987,200	9,410	49,700	34.4	1.49		
B 15 b	48.5	18	7.30	.31	.40	.837	.016	7.50	89.0	949,800	9,410	34,800	33.4	1.53		
B 15 a	72.0	15	7.15	.54	.79	1.203	.020	6.13	106.4	1,134,800	7,850	82,300	55.1	1.61		
B 15 a	54.0	15	7.00	.40	.54	.953	.020	6.21	81.4	868,100	7,850	53,100	37.2	1.53		
B 15	42.0	15	6.74	.36	.35	.749	.020	6.12	62.0	661,200	7,850	44,100	23.4	1.37		
B 12 a	38.0	15	6.66	.28	.35	.749	.020	6.28	59.0	629,200	7,850	28,400	22.5	1.42		
B 12 a	36.0	12	6.30	.31	.39	.764	.025	4.97	37.5	480,300	6,280	32,400	20.4	1.38		
B 12	31.0	12	6.16	.31	.28	.645	.025	5.07	36.1	400,300	6,280	32,000	14.7	1.27		
B 12	28.5	12	6.10	.25	.28	.645	.025	5.07	36.1	385,000	6,280	22,400	14.2	1.30		
B 10	24.5	10	5.85	.25	.24	.590	.029	4.22	25.4	271,300	5,230	21,200	11.1	1.24		
B 10	22.5	10	5.80	.20	.24	.590	.029	4.27	24.6	262,000	5,230	14,600	10.8	1.27		
B 9	21.0	9	5.44	.25	.22	.544	.033	3.78	19.7	210,300	4,710	20,100	8.2	1.15		
B 9	19.0	9	5.38	.19	.22	.544	.033	3.87	18.9	201,800	4,710	13,000	7.9	1.18		
B 8	18.00	8	5.26	.25	.18	.493	.037	3.34	15.0	160,000	4,180	19,000	6.4	1.09		
B 8	16.25	8	5.19	.18	.18	.493	.037	3.44	14.3	152,000	4,180	11,500	6.1	1.12		

TABLE 2.—PROPERTIES OF BETHLEHEM SPECIAL GIRDER BEAMS.

Sec. No.	Weight per Foot, Pounds	Dimensions, in Inches.					Increase of Web and Flange for Each lb. Increase of Weight, Inches.	Radius of Gyration	Neutral Axis Perpendicular to Web at Center.	Section Modulus.	Coefficient of Strength for Fiber Stress of 16,000 lb.	Add to Coefficient for Each lb. Increase in Weight.	Maximum Safe Shear on Web, Pounds.	Neutral Axis Coincident with Center Line of Web.	Moment of Inertia.	Radius of Gyration.
		D.	B.	W.	M.	N.										
G 30 a	200.0	30	15.00	.75	0.830	1.721	.010	12.47	610.3	6,510,000	15,690	190,400	599.7	3.19		
G 30	175.0	30	12.00	.68	1.013	1.721	.010	12.37	523.5	5,583,500	15,690	162,300	346.4	2.60		
G 28 a	180.0	28	14.35	.69	0.805	1.659	.011	11.72	519.2	5,538,200	14,640	162,500	507.6	3.09		
G 28	162.5	28	12.00	.65	0.950	1.659	.011	11.63	461.8	4,925,800	14,640	147,600	328.2	2.62		
G 26 a	160.0	26	13.60	.63	0.775	1.586	.011	10.93	432.2	4,610,200	13,600	136,700	314.5	2.97		
G 26	150.0	26	12.00	.62	0.875	1.586	.011	10.86	400.0	4,267,000	13,600	133,200	306.5	2.63		
G 24 a	140.0	24	13.00	.56	0.720	1.498	.012	10.17	353.5	3,770,700	12,550	109,800	338.3	2.87		
G 24	120.0	24	12.00	.51	0.645	1.363	.012	10.14	302.6	3,227,200	12,550	93,000	240.0	2.61		
G 20 a	140.0	20	12.50	.64	0.830	1.571	.015	8.44	293.8	3,134,200	10,460	124,700	334.3	2.85		
G 20	112.0	20	12.00	.52	0.620	1.338	.015	8.49	239.9	2,526,700	10,460	91,100	232.8	2.66		
G 18	92.0	18	11.50	.47	0.500	1.189	.016	7.67	177.3	1,890,800	9,410	74,200	172.4	2.52		
G 15 b	140.0	15	11.75	.80	0.995	1.679	.020	6.21	212.2	2,263,500	7,850	134,500	319.2	2.78		
G 15 a	104.0	15	11.25	.60	0.680	1.346	.020	6.32	162.6	1,734,700	7,850	93,700	203.3	2.58		
G 15	73.0	15	10.50	.42	0.440	1.070	.020	6.42	118.2	1,260,900	7,850	57,600	116.6	2.33		
G 12 a	70.0	12	10.00	.445	0.500	1.097	.025	5.12	90.2	961,600	6,280	55,900	109.5	2.31		
G 12	55.0	12	9.75	.35	0.340	0.928	.025	5.18	72.0	768,000	6,280	39,400	76.1	2.17		
G 10	44.0	10	9.00	.30	0.300	0.844	.030	4.34	48.9	521,200	5,230	28,700	53.6	2.03		
G 9	38.0	9	8.50	.29	0.265	0.779	.033	3.90	37.7	402,500	4,710	25,700	40.7	1.91		
G 8	32.5	8	8.00	.28	0.230	0.713	.037	3.46	28.5	303,800	4,180	22,700	30.3	1.78		

TABLE 4.—PROPERTIES OF BETHLEHEM H COLUMNS.

Sec. No.	Weight per ft., lbs.	Area of sec- tion, sq. in.	Dimensions, in inches				Axis XX		Axis YY	
			D	T	B	W	Radius of Gyration.	Section Modulus.	Radius of Gyration.	Section Modulus.
H 14	98.8	29.06	14	$\frac{1\frac{13}{16}}$	14.00	.51	6.07	152.8	3.50	50.8
H 14 a	162.2	47.71	15	$\frac{1\frac{5}{8}}$	14.31	.82	6.31	252.7	3.62	87.4
	164.4	48.36	15	$\frac{1\frac{5}{8}}$	14.57	.82	6.32	256.6	3.69	90.6
H 14 b	222.3	65.39	15%	$\frac{1\frac{3}{4}}$	14.84	1.09	6.51	349.5	3.78	126.2
	230.8	67.89	16	$\frac{1\frac{13}{16}}$	14.88	1.13	6.55	363.2	3.80	131.5
	291.2	85.63	16%	$2\frac{1}{4}$	15.16	1.41	6.75	462.0	3.88	170.3
H 13	91.5	26.93	13	$\frac{1\frac{18}{16}}$	13.00	.51	5.61	130.5	3.26	44.1
H 13 a	150.5	44.27	14	$\frac{1\frac{5}{8}}$	13.31	.82	5.84	215.9	3.38	75.9
	156.4	45.99	14	$\frac{1\frac{5}{8}}$	14.00	.82	5.86	225.9	3.57	83.6
H 13 b	219.8	64.64	15	$\frac{1\frac{18}{16}}$	14.31	1.13	6.10	320.7	3.67	121.6
	226.5	66.62	15	$\frac{1\frac{18}{16}}$	14.88	1.13	6.12	332.4	3.83	131.2
	285.9	84.09	15%	$2\frac{1}{4}$	15.16	1.41	6.32	423.6	3.91	169.9
H 12	78.0	22.94	12	$\frac{3}{4}$	12.00	.47	5.18	102.6	3.01	34.7
H 12 a	132.5	38.97	13	$\frac{1\frac{1}{4}}$	12.31	.78	5.41	175.6	3.13	61.9
	138.1	40.61	13	$\frac{1\frac{1}{4}}$	13.00	.78	5.43	184.4	3.32	68.7
H 12 b	197.1	57.96	14	$\frac{1\frac{3}{4}}$	13.31	1.09	5.67	266.0	3.42	101.7
	204.9	60.27	14	$\frac{1\frac{3}{4}}$	14.00	1.09	5.69	278.7	3.61	112.1
	268.8	79.06	15	$2\frac{1}{4}$	14.32	1.41	5.93	370.3	3.71	151.7
H 11	65.5	19.26	11	$\frac{1\frac{11}{16}}$	11.00	.43	4.75	79.0	2.76	26.7
H 11 a	115.5	33.98	12	$\frac{1\frac{9}{8}}$	11.31	.74	4.98	140.5	2.87	49.6
	120.9	35.54	12	$\frac{1\frac{9}{8}}$	12.00	.74	5.00	148.2	3.06	55.6
	175.8	51.70	13	$\frac{1\frac{11}{16}}$	12.32	1.06	5.24	218.0	3.17	84.1
H 10	54.1	15.91	10	$\frac{5}{8}$	10.00	.39	4.32	59.4	2.51	20.1
H 10 a	99.7	29.32	11	$\frac{1\frac{1}{8}}$	10.31	.70	4.55	110.4	2.62	39.1
	104.7	30.80	11	$\frac{1\frac{1}{8}}$	11.00	.70	4.57	117.0	2.81	44.3
	155.2	45.64	12	$\frac{1\frac{5}{8}}$	11.32	1.02	4.80	175.6	2.91	68.4
H 9	43.8	12.88	9	$\frac{9}{16}$	9.00	.35	3.89	43.3	2.26	14.6
H 9 a	85.3	25.08	10	$\frac{1\frac{1}{8}}$	9.32	.67	4.11	84.9	2.37	30.2
	90.0	26.46	10	$\frac{1\frac{1}{8}}$	10.00	.67	4.14	90.5	2.56	34.6
	135.6	39.87	11	$\frac{1\frac{5}{8}}$	10.31	.98	4.38	138.7	2.66	54.6
H 8	34.6	10.17	8	$\frac{1}{2}$	8.00	.31	3.46	30.4	2.01	10.3
H 8 a	71.6	21.05	9	$\frac{1}{2}$	8.32	.63	3.68	63.5	2.12	22.7
	76.0	22.35	9	$\frac{1}{2}$	9.00	.63	3.70	68.2	2.31	26.4
	117.1	34.45	10	$\frac{1\frac{1}{2}}$	9.31	.94	3.94	107.2	2.41	42.8

onstrate the most economical methods of working the special shapes than as a new competitor for structural work.

The large blooming mill and the two Grey mills are being constructed by the Bethlehem Steel Co., with the exception of the engines, which have been built by the Wm. Tod Co. The Mesta Foundry & Machine Co. are the builders of the 40-in. blooming mill, except the Tod engine, and are also building the engines for the 28-in. structural mill and the 28-in. rail mill. The last two mills, except the engines, are being built by the United Engineering & Foundry Co.

Tests of Bond Between Concrete and Steel

A series of tests recently made at Lewis Institute, Chicago, by Prof. C. E. De Puy, to determine the bond between concrete and steel rods, showed some very high results for corrugated bars. In making the tests the strength of bond for various lengths of embedment was measured, also the slip of the bar and the load causing the slips.

The concrete blocks in which the rods were embedded were cylindrical with a diameter of 6 in. and 8, 12, 16, 20 and 24 in. long. Each block had a cast iron base plate, turned to a true face. These blocks were supported upon a spherical bearing block on the top of an Olsen testing machine so that the specimen could be properly adjusted for a direct pull. The lower projecting end of the bar was gripped in the movable head of the machine, the upper end projected $\frac{3}{4}$ in. above the top of the block, while upon the block rested a spherometer with the graduated screw brought into contact with the upper end of the bar, thus closing an electric circuit. As the load came on, the slightest slipping of the bar in the concrete would break the electric circuit, causing a bell to ring until the graduated screw was turned down and the circuit closed. By this means it was possible to measure very accurately the movement of the bars and the load causing the same.

The results of the tests as given by Prof. De Puy and later presented before the Western Society of Engineers by Mr. T. L. Condon, are given in part in an accompanying table. The New Style bars (N) used in these tests were of the size known as $\frac{5}{8}$ -in. with an average cross-sectional area of 0.368 in. The Old Style bars (O) were $\frac{3}{4}$ -in. size with an average area of 0.424 in. The value of the bond per square inch of embedded bar surface has been calculated. For a slip not over $\frac{1}{100}$ in. the value for the New Style bar in various embedments ranges from 452 to 569 lb. with an average of 487. For the Old Style the range is from 535 to 651 and the average 578. For a slip not over $\frac{1}{32}$ in. the New Style shows 506 to 660 lb. with 581 as the average, while the Old Style develops 535 to 786 lb., average 670. With a slip not exceeding $\frac{1}{16}$ in. the

RESULTS OF BOND TESTS WITH CORRUGATED BARS.					
Stresses on bars in lbs. per sq. in. of cross section.					
Embedment, ins.	8	12	16	20	24
Slip not more than $\frac{1}{100}$ in.					
(N).....	23,800	37,500	60,000	61,500	74,500
(O).....	29,200	48,000	53,500	69,400	79,000
Slip not more than $\frac{1}{32}$ in.					
(N).....	33,000	48,400	69,600	68,400	*80,000
(O).....	38,500	58,000	64,100	*73,000	*79,000
Slip not more than $\frac{1}{16}$ in.					
(N).....	40,700	54,200	72,300	72,500	*80,000
(O).....	44,300	58,800	67,500	*73,000	*79,000
Slip not more than $\frac{3}{32}$ in.					
(N).....	40,700	55,800	72,300	73,300	*80,000

*Developed full strength of bond before slipping

$\frac{1}{32}$ in. †Developed full strength of bond before slipping

$\frac{1}{16}$ in. ‡Developed full strength of bond before slipping

$\frac{3}{32}$ in.

range of the New Style bar was from 506 to 775 lb. and the average 640, while the Old Style ranges 535 to 840 lb. with an average of 691. For a slip not over $\frac{3}{32}$ in. the New Style showed a value of 506 to 775 lb. and an average of 646.

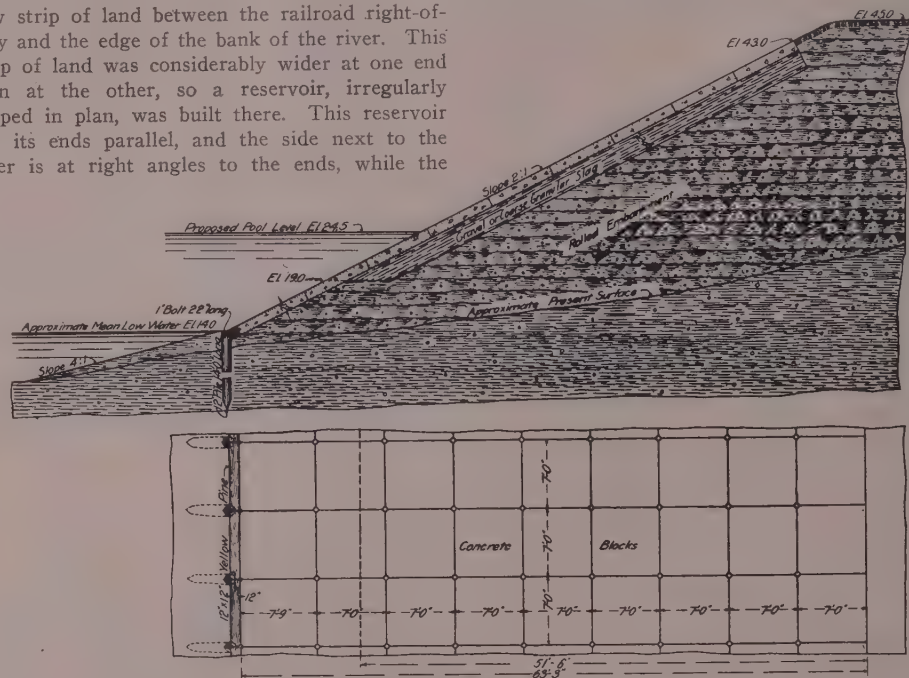
The Pittsburgh Filtration Plant.—III.

Filtered-Water Conduit and Reservoir.—The filtered-water conduit in each gallery into which the effluent from the filters is discharged connects at the end of the gallery nearest the river with a main conduit leading to the filtered-water reservoir. This main conduit is built of reinforced concrete and is of the standard cross-sections adopted for conduits of that type in all parts of the plant. It extends parallel to the railroad right-of-way from the filter gallery farthest upstream to the one farthest downstream and then turns and crosses under the railroad tracks to an inlet-gate chamber at the end of the reservoir, with an increase in size at the junction of the filtered-water conduit from each gallery with it. The height and width of the cross-section are the same in each size of conduit; between the first and second galleries they are 7 ft.; between the second and third galleries, 8 ft. 4 in.; between the third and fourth, 9 ft. 5 in.; and between the fourth gallery and the inlet-gate chamber to the filtered-water reservoir, 10 ft. 4 in.

The only location available for a filtered-water reservoir on either side of the river was a narrow strip of land between the railroad right-of-way and the edge of the bank of the river. This strip of land was considerably wider at one end than at the other, so a reservoir, irregularly shaped in plan, was built there. This reservoir has its ends parallel, and the side next to the river is at right angles to the ends, while the

converge. The spans of the groined arches are thus $15\frac{3}{4}$ ft. in both directions; the rise of these arches is 4 ft. and they have a thickness of 6 in. at the crown. The concrete piers carrying the roof were built in place before the arches were erected on them and the latter are not connected to them.

The variation in the width of the reservoir is all taken up in the first longitudinal bay of groined arches of the roof inside the barrel arches on the skew side of the reservoir, there being sixty-five transverse bays in the reservoir. The skew side of the latter is made straight for 21 ft. at one end and for 39 ft. at the other and the change in width taken up in the remaining length of sixty-three transverse bays. These bays are divided in seven sets of nine bays each and the width gradually reduced 2 ft. to each of the nine bays of a set, so that one 18 ft. bay is eliminated in each set of nine. This arrangement avoided any variation in the more difficultly constructed forms of the barrel arches along the side of the reservoir. It also permitted one set of forms for the irregularly shaped groined arches of the set of nine to be used seven times, and avoided all other irregular forms.



Plan and Section of Embankment and Revetment along Filtered Water Reservoir.

other side is on a 6 deg. skew, the width at one end being 168 ft. and at the other 294 ft., with a total length between the ends of 1,194 ft. The up-stream corner of the river side is on the extreme edge of the natural bank of the river and that end of the reservoir is in line with the downstream gallery of the filters, the distance to which the reservoir could be extended upstream being determined by the contour of the river bank and by the location of this gallery.

The reservoir is built of concrete without reinforcement at any point and has inverted groined arch floors and a groined arch roof carried on concrete piers built on the floor. The extreme end and side bays of the roof are barrel arches of the conduit type, the arch being 6 in. thick at the crown and extending down into the side walls. It is believed that these arches are the largest of this type that have been built. The concrete piers carrying the groined roof arches are 27 in. in diameter and 21.5 ft. high. They are keyed into the concrete of the floor without being attached to the latter, and are not reinforced. They are spaced 18 ft. apart on centers in both directions and are in regular transverse and longitudinal rows except on the skew side of the reservoir where some of the longitudinal rows

It further made possible the use of one set of the difficult forms required at the intersection of the barrel arches at the corners of the reservoir for all four of these corners.

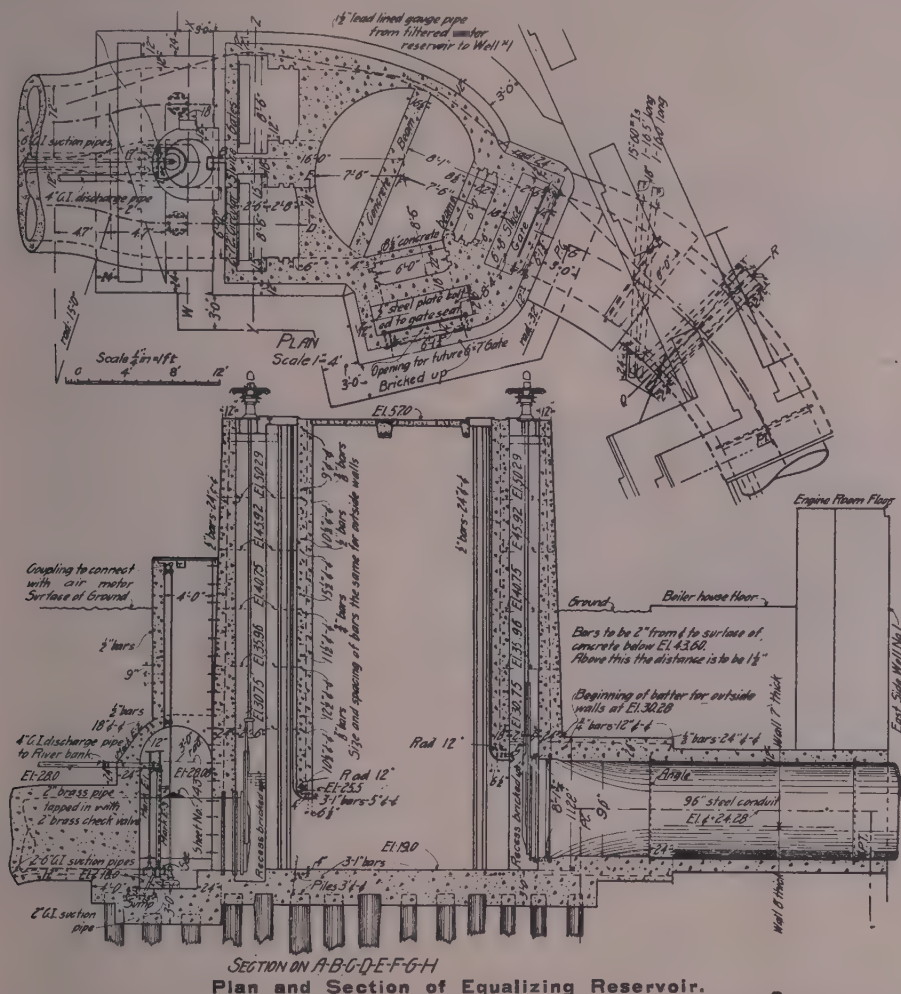
The ground surface of the site on which the reservoir is constructed was all close to the maximum flood line in the river and was underlain at an average depth of 6 ft. by a continuous stratum of good gravel. The excavation for the reservoir was carried on the average about 3.5 ft. below the top of this gravel.

The flood level in the river is at El. 41 as referred to the Pittsburgh datum, and low water in the river is at El. 14. The construction of the dam across the river just below the plant will probably raise the flood level about 2 ft. at the plant and will hold a pool level at El. 24.5. The river side of the reservoir is nearly parallel to and 120 ft. inshore from a harbor line that has been established along the river. An embankment is filled in on the river side of the reservoir out to within 30 ft. of this harbor line, and then down to the bed of the river on a 2 on 1 slope. This slope is protected up to the elevation of extreme floods with a heavy concrete revetment, the details of which are shown in an accompanying illustration. The revetment consists of 7 x 7-ft. concrete blocks,

12 in. thick, which were laid in place on the slope. Along the lower side of this revetment is a row of 12-in. piles, 7 ft. apart on centers and with a 12 x 12-in. waling piece along the top against which the lower course of blocks take bearing. A layer of gravel at least 24 in. thick is placed under the blocks from a point

is a layer of puddle varying from 7 in. in depth along the longitudinal center line of the reservoir to 4 in. in depth at the sides. This puddle is covered with 4 in. of gravel in which are placed longitudinal lines of 2-in. tile extending to a cast-iron pipe in the embankment along both sides of the reservoir. A layer of filling 26 in.

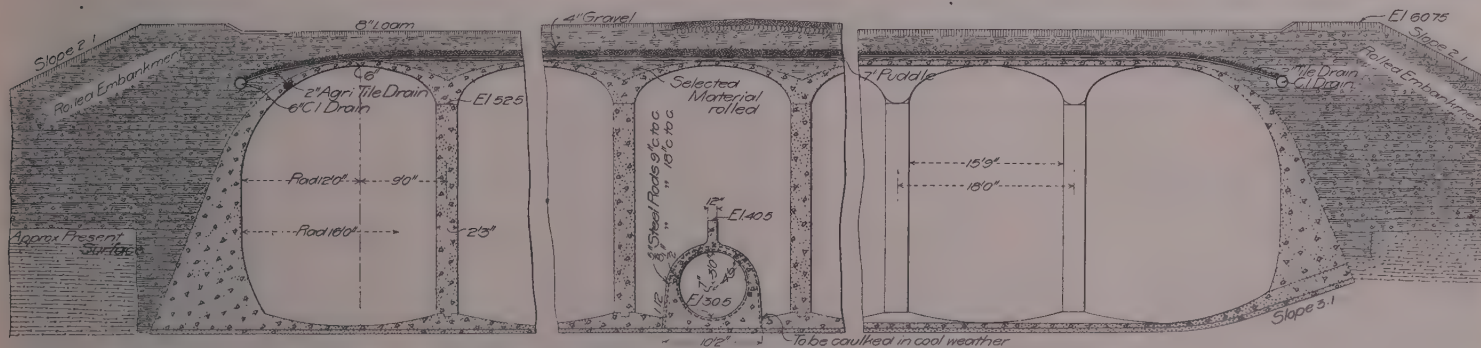
be closed by a sluice gate. Between these two rectangular openings is an 84-in. circular opening that connects the gate chamber with a reinforced concrete by-pass conduit of that size built along on the floor of the reservoir to outlet gate chamber. A cross wall carried up 11 ft. above the floor of the gate chamber separates one of the 6 x 8-ft. openings into the reservoir from the other 6 x 8-ft. outlet from the chamber into the reservoir and also from the connection between the 84-in. by-pass and the chamber. On the top of this wall may be set a removable steel weir by which the flow of water into the chamber and thence into the reservoir may be measured. The connection of that conduit with the gate chamber is made through a very large



Plan and Section of Equalizing Reservoir.



Vaulting in Filtered-Water Reservoir.



Transverse Sections through Filtered-Water Reservoir.

5.5 ft. below the pool level in the river to the top of the revetment. A 4-in. circular hole is also made at the corner intersection of each four blocks to prevent water collecting behind the revetment.

The top of the slope that is protected with this revetment is at El. 45, or 2 ft. above flood level. At that level a berm, varying from 20 to 40 ft. in width is carried back to a second 1 on 2 slope that rises to the level of the fill over the roof of the reservoir.

The fill over the roof of the reservoir has been designed so it is believed that any percolation of water into the reservoir will be prevented. The spaces in the haunches of the groined arches of the roof are brought up to the level of the intrados of the crown of the arch with selected filling material. Over this

thick at the center of the reservoir and 20 in. thick at the sides will be placed over the gravel and will be finished with 8 in. of loam that will be sodded.

The only entrance to the reservoir is through a hatch at the outlet end provided for the admission of a small row boat, and through seventeen ventilators in the roof of the reservoir. The hatch will be closed, except on rare occasions, and the ventilators will be sealed. The only admission of air to the reservoir will be through an opening in the house built over the outlet gate chamber and light will be entirely excluded.

The inlet gate chamber of the filtered-water reservoir has three openings out of it on the reservoir side. One of these is 6 x 8 ft. and a second is 6 x 9 ft. in cross-section and both may

bell mouth in reinforced-concrete which reduces the velocity of approach to the weir sufficiently to make measurements of flow over the latter accurate.

A low dam of concrete is built longitudinally on top of the by-pass conduit in the reservoir to a height of 10.5 ft. above the floor. The by-pass and this low dam separate the reservoir into two longitudinal parts below the crest of the dam. One of the rectangular openings into the reservoir is on each side of the by-pass and the water may be drawn from each side of the reservoir without drawing the water out of the other part below the crest of the low dam.

The outlet gate chamber has three openings into it, one from the 84-in. by-pass laid on the bottom of the reservoir, and two 6 x 8-ft. open-

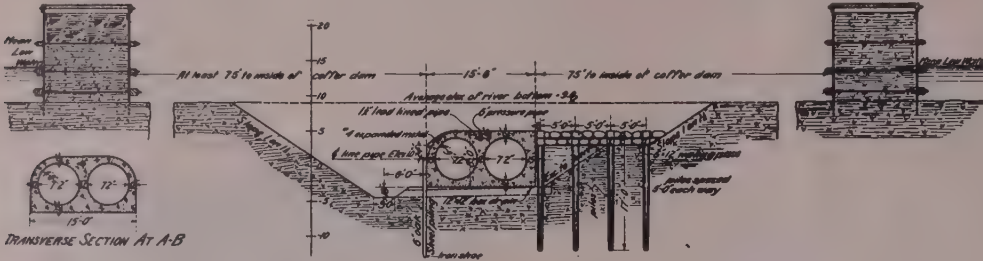
ings directly into the reservoir controlled by sluice gates. The outlet from the chamber is through two 6 x 7-ft. openings which connect with two 72-in. pipes laid under the river to the pumping station at Brilliant, from which the water is lifted to the distribution reservoirs. These two openings are controlled by sluice gates. A third one is provided for connection with a future pipe line across the river, but is closed with a brick wall. The openings in both

The work was all carried on in cofferdams, the excavation and concrete work being done as nearly as possible in the dry. The top of the concrete surrounding the pipes is 4 ft. below the bottom of the river and is reinforced on the upstream corner with a sheet of expanded metal to resist the effects of the ice in case the river bottom should be scoured out by an ice gorge. A row of 6 x 10-in. sheet piling is also placed along the upstream side. On the downstream

lead has a present capacity of approximately 98,000,000 gal. a day, furnished by two 10,000,000-gal. vertical compound Holly pumping engines, two 15,000,000-gal. vertical cross-compound and four 12,000,000-gal. vertical cross-compound Allis-Chalmers pumping engines. These units have their suctions in large wet wells built of stone masonry that have a depth of 45 ft. and are connected with an intake in the river. The suctions of the pumps will all be cut off from the wet wells and connected with a 96-in. riveted-steel suction main, supplied from the 72-in. pipes of the river crossing. This main extends the length of the pump room through the wet wells, 24 ft. above the bottom of the latter. Two 15,000,000-gal. high-duty vertical cross-compound Allis-Chalmers pumping engines are also being added to the equipment and will be installed in the pump room. These units will also have their suctions connected with the 96-in. suction trunk.

The space on the river side of the station building is so limited that no wet wells could be built at the end of the 72-in. pipes. An equalizing chamber built of reinforced concrete has been provided in this limited space, however, in which the 72-in. pipes end and from which the 96-in. suction main starts. This chamber is practically circular with a diameter of 15 ft. and a total height of 38 ft. It was built entirely in excavation and is on piles. The 72-in. pipes enter it at the bottom and the 96-in. suction main connects with it at the same level. The water surface in the chamber will be free and provides for any sudden fluctuations in the pressure in the suction main, or in the 72-in. pipes. Three steel stand-pipes, 5 ft. in diameter and 30 ft. high, are to be placed on the suction main in the station to further provide for fluctuations due to synchronizing of motion in the pumps.

The ends of the 96-in. suction main and of the 72-in. pipe at the equalizing chamber are each provided with a sluice gate placed in concrete built up on the side of the chamber. A connection for an additional suction main is also made with the chamber. This main will supply the pumps in a future station which will have



Section Through Cofferdam at Allegheny River Crossing.

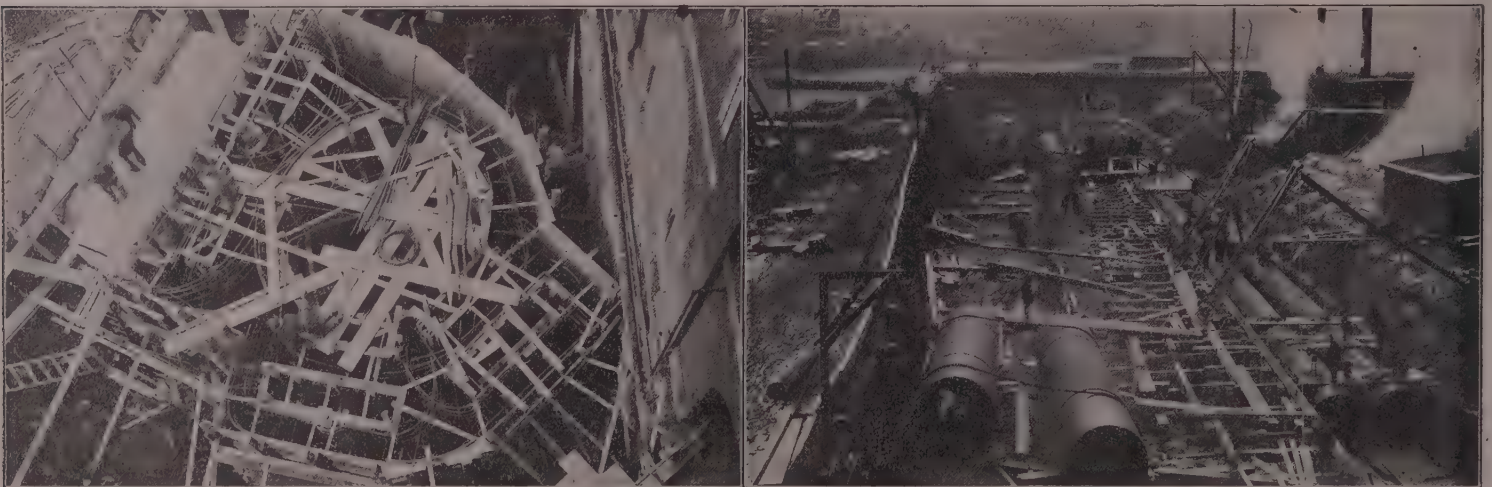
the inlet and outlet gate chambers connecting with the by-pass may be closed with stop planks. All of the openings controlled by sluice gates may be closed in this manner also, as is the usual arrangement throughout the plant where sluice gates are provided.

River Crossing.—A Venturi meter is placed in each of the 72-in. pipes leading across the river. As the head on these pipes is low, a special form of recording apparatus was built to be installed in the gate house. A pressure pipe connects the throat of each meter with a separate float pipe in the gate house, and another pressure pipe connects the upper end of each meter with another float pipe in the gate house. The two floats operate the recording mechanism instead of the latter being operated by mercury as is the usual arrangement. This is the last of four measuring stations by which the quantity of water flowing from various parts of the plant may be obtained and any loss of water located.

The Allegheny River is about 1,000 ft. wide at low water at the point where the double 72-in.



Section of Completed 124-in. Filtered Water Conduit.



Bird's Eye View of Equalizing Chamber Showing Reinforcement; Laying Two 72-in. Pipes of Allegheny River Crossing.

pipe crossing is made. The river bottom is all good gravel and sand to considerable depth, with about 5 ft. of water over it at lowest stage in the river. The gravel and sand have been dredged out in spots to various depths below the natural bottom in the vicinity of the plant to supply the local market. The river is subject to quick rises at frequent intervals and at times carries a large amount of ice and drift-wood.

The two 72-in. pipes have been inclosed in a heavy mass of concrete which is expected to act as a submerged dam. The details of this pipe crossing are shown in one of the illustrations.

side of the concrete, piles were driven in four rows parallel to the pipes and 5 ft. apart on centers in both directions. These piles are all tied together with timbers and around their heads is laid 2 ft. of riprap to prevent the river bottom being scoured out below the concrete on the downstream side. If scour does occur it is considered that the rows of piles will prevent the stone in the riprap from being displaced laterally and will cause it to drop as the scour takes place, and to assume eventually a permanent slope.

Brilliant Pumping Station.—The Brilliant pumping station to which the two 72-in. pipes

to be erected as soon as the capacity of the equipment in the present station is overtaxed.

A large amount of work is also being done in the pumping station in addition to the installation of the two 15,000,000-gal. pumps. The connections and appurtenances in the old wet wells will be completely taken out and replaced by the connections between the new suction trunk and the various pumps. The auxiliary equipment of the station is also being overhauled and some of it replaced.

All of this work is to be done with no small amount of difficulty, for all of the large pumping units in the station have to be kept in service,

and much of the heavy masonry on which parts of some of these units stand, or that in the wet wells, has to be removed.

Three 500-h.-p. water-tube boilers, built by the Stirling Consolidated Boiler Co., have also been added to the equipment of the station. These boilers are equipped with Roney stokers supplied with coal from overhead hoppers to which the coal is elevated from bunkers by a special form of traveling conveyor built by the Link Belt Co.

Pipe Line to South Side.—In connection with the contract for the filtration plant a contract was also awarded to T. A. Gillespie & Co. for the construction of a pipe line leading from the distribution reservoirs supplied from the Brilliant pumping station to the south side of the city and thence under the Monongahela River to supply a part of the city on the south side of that stream. This line is a 50-in. pipe for a distance of about 5 miles to a point on the north side of the river where branches are taken from it to reinforce the present distribution system in that locality. From these branches the line continues across the river as a 36-in. pipe, with a total length of about a mile, and is laid in a trench dredged in the bottom of the river at a point where the latter has 27 ft. of water at low stages. On the south side of the river the line connects with the main of a private water company which at present supplies the portion of the city on that side of the river with unpurified water from the Monongahela River.

General Landscape Plan.—The site of the sedimentation basins, filters and clear-water reservoir of the filtration plant will be seeded and planted with trees and shrubs. The drive which is built over the 60-in. Allegheny water main extends the length of the site and connects with public highways at each end. This drive is depressed below the general elevation of the fill over the filter and will be crossed on bridges by two drives at right angles to it. These latter drives connect with others that extend around the sedimentation basins. A drive through a subway also connects the pumping station grounds on the opposite side of the railroad tracks with the drives through the main portion of the site. These drives will all have macadam roadways and will be open to the public.

The general idea that has been followed in developing the landscape plan has been to isolate the site from the surroundings by hedges and to plant hardy shrubs and trees of small growth which will require pruning at extended intervals only. All attempts at elaborate decorations, such as flower gardens, set plants and fountains have been avoided and the available funds devoted to less showy, but more permanent landscape gardening. A growth of heavy timber on the hill back of the site will be retained. The small trees that are to be planted will be placed along the drives and at a few of the corners. The entrances to the galleries from the drive over the Allegheny water main will be relieved by shrubbery. The entrances to the plant will be closed by iron gates carried by large stone piers. All overhead wires have been avoided by a system of underground ducts in which wires for all purposes will be carried in cables.

(To be Continued.)

THE METRIC SYSTEM of weights and measures has been adopted by the great manufacturing corporation of Kynoch, Ltd., of Birmingham, England. A committee has been appointed to consider the details of the change and to provide the necessary instruments, and as soon as it reports the change will be made. It is understood that all weights and measures will be metric and that for money calculations the pound sterling will be adopted as a unit and will be subdivided decimally.

Book Notes.

It is generally recognized that Dr. E. W. Hilgard, Professor of Agriculture at the University of California, is the leading living authority on soils, a subject he began to study more than fifty years ago when, as a young man trained in the best research methods of Zurich, Freiberg and Heidelberg, he came to this country to take up his chosen specialty in Mississippi. Since that time he has had opportunities better than have fallen to other specialists to examine a great variety of soil types, particularly virgin soils unchanged by centuries of persistent cultivation like those upon which most European research has been directed. His new treatise on "Soils," therefore, must be accepted as the authoritative review of this important subject, which is vitally important to engineers engaged in irrigation, water storage, sewage disposal and flood prevention. It is divided into four parts. The first takes up the formation and origin of soils, and is particularly valuable on account of the excellent treatment of the subject of clay. In the second part, which is the longest of the four, the physics of soils is treated and a great deal of information bearing directly on engineering undertakings in the arid and semi-arid regions is furnished. In the third part the chemistry of soils is taken up and attention may be called specially to two chapters on alkali soils and the reclamation of alkali lands. The last part is on the relation of natural vegetation to soils, and while it is not of so much engineering value as those that preceded it there is much interesting information showing the scientific reasons for many of the facts which are well known among experienced settlers in new country. (New York, The Macmillan Co., \$4.)

Volume 7 of the "Proceedings" of the American Railway Engineering and Maintenance of Way Association is a book of 824 pages, profusely illustrated, containing a well-edited report of the convention held last March. This volume should not only be in the library of every engineering college, but, with the previous volumes, should be available for reference in the important designing offices of all our American railways. The amount of information in these books concerning present practice and the opinions of leading railway engineers as to improvements in such practice is enormous. Nothing like it can be obtained elsewhere, and its value is enhanced by the fact that it is all given authoritatively by committees or individual engineers, and is accordingly free from the lack of individuality which is a defect of anonymous statements. In this volume the subjects covered are, 1, uniform rules for the government of employees of maintenance of way departments; 2, ties, including specifications for treatment; 3, ballasting; 4, yards and terminals; 5, iron and steel structures, including specifications for bridges; 6, records and accounts, including conventional designs for maps; 7, classification of track; 8, roadway, including an elaborate committee report on the treatment of overhaul and a bibliography of the subject; 9, signs, fences, crossings and cattle-guards; 10, signaling and interlocking, including important specifications; 11, rails; 12, masonry; 13, buildings, particularly round-houses; 14, track; 15, water service; 16, wooden bridges and trestles, including specifications. The book is sold by the Association at its office in the Monadnock Block, Chicago.

A valuable book on British shop methods so far as they relate to lathe work has been written by Mr. Joseph G. Horner under the title of "Practical Metal Turning." In an introductory chapter the different machine shop operations are

classified and the field where the different types of lathes are used is pointed out. In the first section of the book, the different types of lathes and the work they do are explained, the forms and functions of the tools are described, and there is a chapter on turning in general. The second section is devoted exclusively to turning between centers; the methods of mounting and steadying the work are explained, both for simple pieces and twisted or bent shapes, and there is a special chapter on mandrel work. In the third section, the handling of work supported at one end is explained. Face-plate turning is taken up first, then angle-plate turning and finally work done with a great variety of chucks. In section four, drilling, boring and allied operations done on a lathe are explained. Section five opens with a chapter on screw cutting, which is followed by one on turret work that will be worth the price of the book to any one who wishes to get a clear idea of the routine possibilities of turret lathes. In the sixth section, there is an account of the miscellaneous work, such as grinding, done on a lathe, and the errors to which turning is liable; various forms of tool holders are described, and there is a long chapter on speeds, feeds and tool steels. There is nothing in the book intended specially for the amateur or the all-around mechanic, as the author's purpose is to explain standard turning in manufacturing establishments rather than job shops. He has accomplished this object in a decidedly creditable manner. (New York, Norman W. Henley Publishing Co., \$3.50.)

One of the most noticeable features of municipal activity at the present time is the general attention paid to smoke prevention. It is true that very little has been accomplished as yet outside of a few cities, but the necessity of abating the nuisance due to smoky atmospheres has at last been widely recognized. So long as the movement for such a reform was based on æsthetic arguments little heed was given to it; but as soon as merchants recognized the damage to their stocks of goods and property owners learned how dirty exteriors reduced the value of their buildings, the demand for relief assumed a more definite character. Unfortunately few people really understand enough about the phenomena of combustion and the effect of furnace construction on smoke production to be able to talk to good advantage on the subject, and accordingly when the owner of a manufacturing plant which belches forth soot all day assures the municipal authorities that there is really no way to stop the smoke except to close down the works, his argument generally wins out. 'As a rule the owner of a plant is just as ignorant as anybody else about smoke prevention, but is able to conceal his ignorance by pointing out that while nearly 1,500 patents have been issued in this country relating to boiler furnaces, hardly any of them have ever had any use whatever, and it was not right to force him to undertake an expensive investigation for an end others had tried in vain to attain. In view of this condition of affairs, it is gratifying to announce the appearance of a book entitled "Combustion and Smokeless Furnaces," by Joseph W. Hays, containing a discussion of the subject within the comprehension of people without technical education. In the first chapter the phenomena of heat and combustion are discussed, and in the second the phenomena of combustion in a boiler furnace are explained, special attention being given to those conditions which tend to prevent complete combustion. The author explains why a smokeless chimney does not necessarily denote perfect combustion and points out the important roles played by air and high temperature in burning the gases given off from the bed of fuel. At the close of the chapter he draws the following

conclusions: "First, that smoke means waste; second, that under right conditions smoke may be consumed and thus prevented from escaping from a chimney; third, that smoke may be burned without securing any economy, because complete combustion does not necessarily mean the arrest of waste; fourth, that complete combustion coupled with proper air regulation, means a large saving of fuel, and that if combustion is improved without such saving the fault may be charged to improper regulation of the air entering the fire-box. The third chapter explains some of the effects of boiler arrangement on combustion, and in the next chapter there is a long discussion of various aspects of the smoke nuisance. With chapter five, on smokeless furnaces in general, the remedies proposed for abating the smoke nuisance are taken up. The first type are mechanical stokers, and the defects of the various types which the author believes to exist are described, very much more stress being laid on them than on their advantages. In the next chapter he describes the various classes of devices employed with hand-fired furnaces to prevent smoke, particularly steam jets, special methods of air admission, arches, Dutch ovens and down-draft furnaces. In his endeavor to prevent the possible purchaser of such apparatus from being deceived as to what it may reasonably be expected to accomplish, Mr. Hays forgets to give praise where praise is due in the same proportion as he gives condemnation, and as a result the reader may lay down the book after a hasty perusal with a feeling that after all there is nothing that can be done to prevent smoke, which is just the idea that the author does not wish to convey. (New York, Hill Publishing Co.)

Letters to the Editor.

PRESERVATION OF PAVEMENTS.

SIR: In your issue of Dec. 8th, I note an editorial on the "Preservation of Pavements." It may be a matter of interest to know how this question is handled in one portion of New York City, namely, the Borough of Richmond.

The charter of New York City places upon the president of each borough full control of all matters pertaining to the opening of street pavements and their restoration, with, perhaps one exception, in that the Department of Water Supply, Gas & Electricity. (a general department exercising control over the whole city), has jurisdiction over sub-surface structures other than sewers. In Richmond, however, there is no clash of authority, for that department works in full harmony with the president of the borough, granting permits for necessary work, subject to the consent of the president for all matters concerning the back-filling of trenches and restoration of pavements, while the president of the borough grants no permit for sub-surface work that does not first receive the consent of the other department.

Now, to the method of operation. There are under presidential responsibility, various bureaus, each with a superintendent, and each having charge of some department of the public work. Of these, the bureaus of highways and sewers have to do specifically with street opening and street maintenance matters. All bureaus come under the general control of the commissioner of public works; the assistant commissioner taking charge of the issuance of permits, and the Bureau of Highways, of back-fill supervision and restoration of pavements.

The general procedure is as follows: A corporation, plumber, or other individual, wishes to make a sewer connection. A signed application is made, is approved by the assistant commissioner, the necessary inspection, back-fill super-

vision and pavement restoration fees are deposited, the permit is issued, the work is done and the street pavement is replaced in safe condition by the applicant, the inspector files his report and the superintendent of highways takes the case under his care. He assigns, as occasion may require, skilled workmen for making the permanent and perfect repair of the pavement, when, in his judgment, it can safely be made.

Precisely the same procedure is followed in all cases where the pavement is opened, except that when the pavements are still subject to maintenance contracts by the companies which have laid them; then an order is issued to said companies to make the repair; but in every instance, the city first requires payment of the moneys which shall be needed for the full repair, before a permit for the work is issued.

The careful carrying out of this system has secured for Richmond practically complete freedom from poor work and uneven street surfacing, and many miles of gas mains, water mains, sewers, telephone conduits and service branches have been placed practically without annoyance to the public and without loss to the city.

Yours very truly, LOUIS L. TRIBUS.
NEW BRIGHTON, Dec. 12. Commissioner.

FORMULAS FOR REINFORCED CONCRETE BEAMS.

SIR: In Mr. J. L. Campbell's letter in your issue of Dec. 1, containing concrete beam formulas, it is not clear how he can call " p/t = percentage of steel in terms of concrete above neutral axis," when " p = mean pressure per square inch in concrete in compression," and " t = tension per square inch in steel." His use of a mean pressure is rather novel, and is especially interesting when he finds that the value of " a = the area of concrete in compression multiplied by p/t ." The formulas 1 to 5 are the ones usually employed, when a proper change of notation has been made to correspond with Mr. Campbell's work. He, however, has entirely omitted the condition of equality of total tension and compression.

As to the assumed values of u , the writer can only state his opinion of their being very conservative. In assuming a ratio of 4 between u and p , the same conservatism is shown. In this particular instance the usual inconsistency is maintained of employing different factors for concrete and steel. It must be admitted that few engineers are consistent in this respect and that the inconsistent ones err on the side of safety. It is considered, further, that the assumed values of r are in error. No tests with which the writer is conversant show the wide range assumed by Mr. Campbell and the values are too low when gauged by Talbot's experiments with beams.

The writer agrees with your correspondent in advocating the inverted "U" type of stirrup and in making use of them through the whole length of a beam. Experiments have shown, however, the advantage of using stirrups spaced closer together than the effective depth of the beam, and of using thus a larger number of smaller section. The advisability of employing stirrups of varying strength in a single beam is strongly questioned from the standpoint of economy of workmanship. It would seem better to have them of constant size and variable spacing. Furthermore, why the concrete and steel are each allowed 50 per cent. of the shear at all points, when the concrete has a constant cross-section and consequently a constant shearing resistance, is not obvious. Near the ends of short beams designed primarily to resist bending, the concrete may be very deficient even to resist but 50 per cent. of the computed shear, while many long beams are amply strong without any stirrups. It would be very interesting to learn how Mr. Campbell computes the

sizes of his varying shear members and what unit stresses he allows on concrete in shear.

It is inferred from the last paragraph of your correspondent's letter that he would not employ plain round rods where stresses of 16,000 lb. are to be assumed. This is probably due to a point often put forward that such rods are deficient in adhesive stress as compared with deformed bars, and also deficient in proportion to their tensile stress. One has only to use more bars of smaller diameter but of any required aggregate area in any given case, to so increase the total circumference that any desired adhesive strength can be secured. Thus, round bars may be as effective as any other design when properly selected. It is to be noted, further, that with numerous stirrups firmly wrapped around the tension rods, such as Mr. Campbell advocates, no special care need be exercised as to adhesion. The experiment reported by the writer to the American Society of Civil Engineers not long since showed this point rather startlingly.

Yours truly,
NEW YORK, Dec. 15. E. P. GOODRICH.

EXPANSION JOINTS IN CONCRETE.

SIR: Thinking that other readers of your valuable journal would likely be interested in the question as to the advisability of, and how to secure, practical expansion joints in concrete structures, I submit the following: I have on hand the construction of a concrete wall, which is to be 30 ft. above footing course, 4 ft. thick at base, and 2 ft. thick at top. The longest straight line of wall is several hundred feet. The intention is to build in sections of about 100 ft. in length. The ends of sections are to be kept in alignment by a vertical tongue and groove formed in the concrete.

Contraction may be provided for by placing in the joint between the ends of sections, Hydrex felt or other similar material; but where the concrete is placed during a spell of comparatively cool weather, say 35° to 60° Fahr., there would be a tendency in the concrete to expand with an increase in temperature. As the co-efficient of expansion in Portland cement concrete is practically 0.00008, which would approximate 0.1 in. in a section of wall 100 ft. long, for a variation of 10° in temperature, theoretically there should be provided an open joint varying from 0.1 in. to more in proportion as the temperature at the time of placing the concrete was 10° or more below an assumed maximum temperature for the locality. Of course, I am aware that the actual expansion in the wall would not correspond to the theoretical expansion of a beam for instance, owing to the influence of such uncertain factors as friction on the foundation and tendency toward equalization in the temperature of wall varying with its thickness, exposure, etc.

The question is: Is it necessary or advisable to allow for expansion at all, and, if so, what practical method to adopt to secure such allowance.

In the several articles that I have noticed during the past year appearing in The Engineering Record where so-called expansion joints were constructed in concrete work, it seemed to me that allowance had been made only for contraction, as in no case was the material inserted in the joint compressible to any material extent. Would be pleased to hear, through the columns of this journal, from any who have had experience on this subject.

ATLANTA, GA. W. H. FOSTER.

THE CAPE COD SHIP CANAL has been taken up by August Belmont & Co. and will be pushed forward rapidly to completion, which is estimated to be about three years hence. Mr. Wm. Barclay Parsons will have charge of the work.



Married Quarters, Culebra.



Temporary Camp, Gatun.

SPECIAL MESSAGE OF PRESIDENT ROOSEVELT ON THE PANAMA CANAL.

HIS ACCOUNT OF WHAT HE SAW ON THE ISTHMUS AND HIS OPINIONS REGARDING THE CANAL.

In the month of November I visited the Isthmus of Panama, going over the Canal Zone with considerable care; and also visited the cities of Panama and Colon, which are not in the Zone or under the United States flag, but as to which the United States Government, thru its agents, exercises control for certain sanitary purposes.

The U. S. S. *Louisiana*, on which I was, anchored off Colon about half past 2 on Wednesday afternoon, Nov. 14. I came aboard her, after my stay on shore, at about half past 9 on Saturday evening, Nov. 17. On Wednesday afternoon and evening I received the President of Panama and his suite, and saw members of the Canal Commission, and various other gentlemen, perfecting the arrangement for my visit, so that every hour that I was ashore could be employed to advantage. I was three days ashore—not a sufficient length of time to allow of an exhaustive investigation of the minutiae of the work of any single department, still less to pass judgment on the engineering problems, but enough to enable me to get a clear idea of the salient features of the great work and of the progress that has been made as regards the sanitation of the Zone, Colon, and Panama, the caring for and housing of the employees, and the actual digging of the canal. The Zone is a narrow strip of land, and it can be inspected much as one can inspect 50 or 60 miles of a great railroad, at the point where it runs thru mountains or overcomes other natural obstacles.

I chose the month of November for my visit partly because it is the rainiest month of the year, the month in which the work goes forward at the greatest disadvantage and one of the two months which the medical department of the French Canal Co. found most unhealthy.

Immediately after anchoring on the afternoon of Wednesday there was a violent storm of wind and rain. From that time we did not again see the sun until Saturday morning, the rain continuing almost steadily, but varying from a fine drizzle to a torrential down-pour. During that time in fifteen minutes at Cristobal 1.05 in. of rain fell; from 1 to 3 a. m., Nov. 16, 3.2 in. fell, and for the six days ending noon, Nov. 16, 10.24 in. fell; for the 24 hours ending noon, Nov. 16, 4.68 in.

in, fell. The Chagres rose in flood to a greater height than it had attained during the last fifteen years, tearing out the track in one place. It would have been impossible to see the work going on under more unfavorable weather conditions. On Saturday, Nov. 17, the sun shone now and then for a few minutes, altho the day was generally overcast and there were heavy showers at intervals.

First Day Ashore.—On Thursday morning we landed at about half past seven and went slowly over the line of the Panama Ry., ending with an expedition in a tug at the Pacific entrance of the canal out to the islands where the dredging for the canal will cease. We took our dinner at one of the eating houses furnished by the Commission for the use of the Government employees—no warning of our coming being given. I inspected the Ancon Hospital, going thru various wards both for white patients and for colored patients. I inspected portions of the constabulary (Zone police), examining the men individually. I also examined certain of the schools and saw the school children, both white and colored, speaking with certain of the teachers. In the afternoon of this day I was formally received in Panama by President Amador, who, together with the Government and all the people of Panama, treated me with the most considerate courtesy, for which I hereby extend my most earnest thanks. I was driven thru Panama and in a public square was formally received and welcomed by the President and other members of the Government; and in the evening I attended a dinner given by the President, and a reception, which was also a Government function. I also drove thru the streets of Panama for the purpose of observing what had been done. We slept at the Hotel Tivoli, at Ancon, which is on a hill directly outside of the city of Panama, but in the Zone.

Second Day.—On Friday morning we left the hotel at 7 o'clock and spent the entire day going thru the Culebra cut—the spot in which most work will have to be done in any event. We watched the different steam shovels working; we saw the drilling and blasting; we saw many of the dirt trains (of the two different types

used), both carrying the earth away from the steam shovels and depositing it on the dumps—some of the dumps being run out in the jungle merely to get rid of the earth, while in other cases they are being used for double tracking the railway, and in preparing to build the great dams. I visited many of the different villages, inspecting thoroughly many different buildings—the local receiving hospitals, the houses in which the unmarried white workmen live, those in which the unmarried colored workmen live; also the quarters of the white married employees and of the married colored employees; as well as the commissary stores, the bath houses, the water-closets, the cook sheds for the colored laborers, and the Government canteens, or hotels, at which most of the white employees take their meals. I went thru the machine shops. During the day I talked with scores of different men—superintendents and heads of departments, divisions, and bureaus; steam-shovel men, machinists, conductors, engineers, clerks, wives of the American employees, health officers, colored laborers, colored attendants, and managers of the commissary stores where food is sold to the colored laborers; wives of the colored employees who are married. In the evening I had an interview with the British consul, Mr. Mallet, a gentleman who for many years has well and honorably represented the British Government on the Isthmus of Panama and who has a peculiar relation to our work because the bulk of the colored laborers come from the British West Indies. I also saw the French consul, Mr. Gey, a gentleman of equally long service and honorable record. I saw the lieutenants, the chief executive and administrative officers, under the engineering and sanitary departments. I also saw and had long talks with two deputations—one of machinists and one representing the railway men of the dirt trains—listening to what they had to say as to the rate of pay and various other matters and going over, as much in detail as possible, all the different questions they brought up. As to some matters I was able to meet their wishes; as to others, I felt that what they requested could not be done consistently with my duty to the United States Government as a whole; as to yet others I reserved judgment.



Mess Tent in the Temporary Camp at Gatun.



Shirtsleeves Mess Hall at Culebra.

ment among all people competent to judge that the Panama route, the one actually chosen, is much superior to both the Nicaragua and Darien routes.

Preliminary Work Being Done.—The wisdom of the canal management has been shown in nothing more clearly than in the way in which the foundations of the work have been laid. To have yielded to the natural impatience of ill-informed outsiders and begun all kinds of experiments in work prior to a thorough sanitation of the Isthmus, and to fairly satisfactory working out of the problem of getting and keeping a sufficient labor supply, would have been disastrous. The various preliminary measures had to be taken first; and these could not be taken so to allow us to begin the real work of construction prior to Jan. 1 of the present year. It then became necessary to have the type of the canal decided, and the only delay has been the necessary delay until the 29th day of June, the date when the Congress definitely and wisely settled that we should have an 85-ft. level canal. Immediately after that the work began in hard earnest and has been continued with increasing vigor ever since; and it will continue so to progress in the future. When the contracts are let the conditions will be such as to insure a constantly increasing amount of performance.

ditions healthy. Everywhere are to be seen the drainage ditches which in removing the water have removed the breeding places of the mosquitoes, while the whole jungle is cut away for a considerable space around the habitations, thus destroying the places in which the mosquitoes take shelter. These drainage ditches and clearings are in evidence in every settlement, and, together with the invariable presence of mosquito screens around the piazzas, and of mosquito doors to the houses, not to speak of the careful fumigation that has gone on in all infected houses, doubtless explain the extraordinary absence of mosquitoes. As a matter of fact, but a single mosquito, and this not of the dangerous species, was seen by any member of our party during my three days on the Isthmus. Equal care is taken by the inspectors of the health department to secure cleanliness in the houses, and proper hygienic conditions of every kind.

I inspected between twenty and thirty water-closets, both those used by the white employees and those used by the colored laborers. In almost every case I found the conditions perfect. In but one case did I find them really bad. In this case, affecting a settlement of unmarried white employees, I found them very bad indeed, but the buildings were all inherited from the French company and were being used temporarily while

spected the receiving hospitals in various settlements. I went thru a number of the wards in which the colored men are treated, a number of those in which the colored men are treated—Americans and Spaniards. Both white men and black men are treated exactly alike, and their treatment is as good as that which could be obtained in our first-class hospitals at home. All the patients that I saw, with one or two exceptions, were laborers or other employees on the canal works and railways, most of them being colored men of the ordinary laborer stamp. Not only are the men carefully cared for whenever they apply for care, but so far as practicable a watch is kept to see that if they need it they are sent to the hospitals, whether they desire to go or not. From no responsible source did any complaint come to me as to the management of the hospital service, altho occasionally a very ignorant West India negro when he is first brought into the hospital becomes frightened by the ordinary hospital routine.

Health Showing Remarkably Good.—Just at present the health showing on the Isthmus is remarkably good—so much better than in most sections of the United States that I do not believe that it can possibly continue at quite its present average. Thus, early in the present year a band of several hundred Spaniards were brought



View in Bas Obispo Cut, Showing Character of Material to be Excavated.

Successful Sanitation.—The first great problem to be solved, upon the solution of which the success of the rest of the work depended, was the problem of sanitation. This was from the outset under the direction of Dr. W. C. Gorgas, who is to be made a full member of the Commission. It must be remembered that his work was not mere sanitation as the term is understood in our ordinary municipal work. Thruout the Zone and in the two cities of Panama and Colon, in addition to the sanitation work proper, he has had to do all the work that the Marine-Hospital Service does as regards the Nation, that the health department officers do in the various States and cities, and that Colonel Waring did in New York, when he cleaned its streets. The results have been astounding. The Isthmus had been a byword for deadly unhealthfulness. Now, after two years of our occupation the conditions as regards sickness and the death rate compare favorably with reasonably healthy localities in the United States. Especial care has been devoted to minimizing the risk due to the presence of those species of mosquitoes which have been found to propagate malarial and yellow fevers. In all the settlements, and little temporary towns or cities composed of the white and black employees, which grow up here and there in the tropic jungle as the needs of the work dictate, the utmost care is exercised to keep the con-

other buildings were in the course of construction; and right near the defective water-closet a new and excellent closet with a good sewer pipe was in process of construction and nearly finished. Nevertheless this did not excuse the fact that the bad condition had been allowed to prevail. Temporary accommodations, even if only such as soldiers use when camped in the field, should have been provided. Orders to this effect were issued. I append the report of Dr. Gorgas on the incident. I was struck, however, by the fact that in this instance, as in almost every other where a complaint was made which proved to have any justification whatever, it appeared that steps had already been taken to remedy the evil complained of, and that the trouble was mainly due to the extreme difficulty, and often impossibility, of providing in every place for the constant increase in the number of employees. Generally the provision is made in advance, but it is not possible that this should always be the case; when it is not there ensues a period of time during which the conditions are unsatisfactory, until a remedy can be provided; but I never found a case where the remedy was not being provided as speedily as possible.

Hospitals and Their Treatment.—I inspected the large hospitals at Ancon and Colon, which are excellent examples of what tropical hospitals should be. I also in-

to the Isthmus as laborers, and additions to their number have been made from time to time; yet since their arrival in February last but one of those Spaniards thus brought over to work on the canal has died of disease, and he of typhoid fever. Two others were killed, one in a railroad accident, and one by a dynamite explosion. There has been for the last six months a well-nigh steady decline in the death rate for the population of the Zone, this being largely due to the decrease in deaths from pneumonia, which has been the most fatal disease on the Isthmus. In October there were 99 deaths of every kind among the employees of the Isthmus. There were then on the rolls 5,500 white, seven-eighths of them being Americans. Of these whites but two died of disease, and as it happened neither man was an American. Of the 6,000 white Americans, including some 1,200 women and children, not a single death has occurred in the past three months, whereas in an average city in the United States the number of deaths for a similar number of people in that time would have been about thirty from disease. This very remarkable showing can not of course permanently obtain, but it certainly goes to prove that if good care is taken the Isthmus is not a particularly unhealthy place. In October, of the 19,000 negroes on the roll 86 died from disease; pneumonia being the most destructive disease, and ma-

larial fever coming second. The difficulty of exercising a thoro supervision over the colored laborers is of course greater than is the case among the whites, and they are also less competent to take care of themselves, which accounts for the fact that their death rate is so much higher than that of the whites, in spite of the fact that they have been used to similar climatic conditions. Even among the colored employees it will be seen that the death rate is not high.

Diminution of Mosquitoes.—In Panama and Colon the death rate has also been greatly reduced, this being directly due to the vigorous work of the special brigade of employees who have been inspecting houses where the stegomyia mosquito is to be found, and destroying its larvæ and breeding places, and doing similar work in exterminating the malarial mosquitoes—in short, in performing all kinds of hygienic labor. A little over a year ago all kinds of mosquitoes, including the two fatal species, were numerous about the Culebra cut. In this cut during last October every room of every house was carefully examined, and only two mosquitoes, neither of them of the two fatal species, were found. Unflinching energy in inspection and in disinfecting and in the work of draining and of clearing brush are responsible for the change. I append Dr. Gorgas's report on the health conditions; also a letter from Surgeon-General Rixey to Dr. Gorgas. The Surgeon-General reported to me that the hygienic conditions on the Isthmus were about as good as, for instance, those in the Norfolk Navy Yard.

Corozal, some 4 miles from La Boca, was formerly one of the most unsanitary places on the Isthmus, probably the most unsanitary. There was a marsh and pond in the middle. Dr. Gorgas had both the marsh and pond drained and the brush cleared off, so that now, when I went over the ground, it appeared like a smooth meadow intersected by drainage ditches. The breeding places and sheltering spots of the dangerous mosquitoes had been completely destroyed. The result is that Corozal for

been made. Colon is built on a low coral island, covered at more or less shallow depths with vegetable accumulations or mold, which affords sustenance and strength to many varieties of low-lying tropical plants. One-half of the surface of the island is covered with water at high tide, the average height of the land being $1\frac{1}{2}$ ft. above low tide. The slight undulations furnish shallow, natural reservoirs or fresh-water breeding places for every variety of mosquito, and the ground tends to be lowest in the middle. When the town was originally built no attempt was made to fill the low ground, either in the streets or on the building sites, so that the entire surface was practically a quagmire; when the quagmire became impassable certain of the streets were crudely improved by filling especially bad mud holes with soft rock or other material. In September, 1905, a systematic effort was begun to formulate a general plan for the proper sanitation of the city; in February last temporary relief measures were taken, while in July the prosecution of the work was begun in good earnest. The results are already visible in the sewerage, draining, guttering and paving of the streets. Some four months will be required before the work of sewerage and street improvement will be completed, but the progress already made is very marked. Ditches have been dug thru the town, connecting the salt water on both sides, and into these the ponds, which have served as breeding places for the mosquitoes, are drained. These ditches have answered their purpose, for they are probably the chief cause of the astonishing diminution in the number of mosquitoes. More ditches of the kind are being constructed.

Colon Water Supply.—It was not practicable, with the force at the Commission's disposal, and in view of the need that the force should be used in the larger town of Panama, to begin this work before early last winter. Water mains were then laid in the town and water was furnished to the people early in March from a tem-

doubtedly very bad; as bad as Pennsylvania Ave. in Washington before Grant's administration. Front St. is already in thoroughly satisfactory shape, however. Some of the side streets are also in good condition. In others the change in the streets is rapidly going on. Thru three-fourths of the town it is now possible to walk, even during the period of tremendous rain, in low shoes without wetting one's feet, owing to the rapidity with which the surface water is carried away in the ditches. In the remaining one-fourth of the streets the mud is very deep—about as deep as in the ordinary street of a low-lying prairie river town of the same size in the United States during early spring. All men to whom I spoke were a unit in saying that the conditions of the Colon streets were 100 per cent. better than a year ago. The most superficial examination of the town shows the progress that has been made and is being made in macadamizing the streets. Complaint was made to me by an entirely reputable man as to the character of some of the material used for repairing certain streets. On investigation the complaint proved well founded, but it also appeared that the use of the material in question had been abandoned, the Commission after having tried it in one or two streets finding it not appropriate.

Complaints Not Well Founded.—The result of the investigation of this honest complaint was typical of what occurred when I investigated most of the other honest complaints made to me. That is, where the complaints were not made wantonly or maliciously, they almost always proved due to failure to appreciate the fact that time was necessary in the creation and completion of this Titanic work in a tropic wilderness. It is impossible to avoid some mistakes in building a giant canal thru jungle-covered mountains and swamps, while at the same time sanitating tropic cities, and providing for the feeding and general care of from twenty to thirty thousand workers. The complaints brought to me, either of insufficient provision in caring for some of the labor-



Laying Brick Pavement in Panama.



Pavement on Front Street, Colon.

the last six months (like La Boca, which formerly also had a very unsanitary record), shows one of the best sick rates in the Zone, having less than 1 per cent. a week admitted to the hospital. At Corozal there is a big hotel filled with employees of the Isthmian Canal Commission, some of them with their wives and families. Yet this healthy and attractive spot was stigmatized as a "hog wallow" by one of the least scrupulous and most foolish of the professional scandal-mongers who from time to time have written about the Commission's work.

Improvements in Panama and Colon.—The sanitation work in the cities of Panama and Colon has been just as important as in the Zone itself, and in many respects much more difficult; because it was necessary to deal with the already existing population, which naturally had scant sympathy with revolutionary changes, the value of which they were for a long time not able to perceive. In Colon the population consists largely of colored laborers who, having come over from the West Indies to work on the canal, abandon the work and either take to the brush or lie idle in Colon itself; thus peopling Colon with the least desirable among the imported laborers, for the good and steady men of course continue at the work. Yet astonishing progress has been made in both cities. In Panama 90 per cent. of the streets that are to be paved at all are already paved with an excellent brick pavement laid in heavy concrete, a few of the streets being still in process of paving. The sewer and water services in the city are of the most modern hygienic type, some of the service having just been completed.

In Colon the conditions are peculiar, and it is as regards Colon that most of the very bitter complaint has

porary reservoir. This reservoir proved to be of insufficient capacity before the end of the dry season and the shortage was made up by hauling water over the Panama railroad, so that there was at all times an ample supply of the very best water. Since that time the new reservoir back of Mount Hope has been practically completed. I visited this reservoir. It is a lake over a mile long and half a mile broad. It now carries some 500,000,000 gal. of first-class water. I forward herewith a photograph of this lake, together with certain other photographs of what I saw while I was on the Isthmus. Nothing but a cataclysm will hereafter render it necessary in the dry season to haul water for the use of Colon and Cristobal.

One of the most amusing (as well as dishonest) attacks made upon the Commission was in connection with this reservoir. The writer in question usually confined himself to vague general mendacity; but in this case he specifically stated that there was no water in the vicinity fit for a reservoir (I drank it, and it was excellent), and that this particular reservoir would never hold water anyway. Accompanying this message, as I have said above, is a photograph of the reservoir as I myself saw it, and as it has been in existence ever since the article in question was published. With typical American humor, the engineering corps still at work at the reservoir have christened a large boat which is now used on the reservoir by the name of the individual who thus denied the possibility of the reservoir's existence.

Colon Pavements.—I rode thru the streets of Colon, seeing them at the height of the rainy season, after two days of almost unexampled downpour, when they were at their very worst. Taken as a whole they were un-

ers, or of failure to finish the pavements of Colon, or of failure to supply water, or of failure to build wooden sidewalks for the use of the laborers in the rainy season, on investigation proved, almost without exception, to be due merely to the utter inability of the Commission to do everything at once.

For instance, it was imperative that Panama, which had the highest death rate and where the chance of a yellow fever epidemic was strongest, should be cared for first; yet most of the complaints as to the delay in taking care of Colon were due to the inability or unwillingness to appreciate this simple fact. Again, as the thousands of laborers are brought over and housed, it is not always possible at the outset to supply wooden walks and bath houses, because other more vital necessities have to be met; and in consequence, while most of the settlements have good bath houses, and, to a large extent at least, wooden walks, there are plenty of settlements where wooden walks have not yet been laid down, and I visited one where the bath houses have not been provided. But in this very settlement the frames of the bath houses are already up, and in every case the utmost effort is being made to provide the wooden walks. Of course, in some of the newest camps tents are used pending the building of houses. Where possible, I think detached houses would be preferable to the semidetached houses now in general use.

Unjust Criticism.—Care and forethought have been exercised by the Commission, and nothing has reflected more credit upon them than their refusal either to go ahead too fast or to be deterred by the fear of criticism from not going ahead fast enough. It is curious to note the fact that many of the most severe critics of the

Commission criticize them for precisely opposite reasons, some complaining bitterly that the work is not in a more advanced condition, while the others complain that it has been rushed with such haste that there has been insufficient preparation for the hygiene and comfort of the employees. As a matter of fact neither criticism is just. It would have been impossible to go quicker than the Commission has gone, for such quickness would have meant insufficient preparation. On the other hand, to refuse to do anything until every possible future contingency had been met would have caused wholly unwarranted delay. The right course to follow was exactly the course which has been followed. Every reasonable preparation was made in advance, the hygienic conditions in especial being made as nearly perfect as possible; while on the other hand there has been no timid refusal to push forward the work because of inability to anticipate every possible emergency, for, of course, many defects can only be shown by the working of the system in actual practice.

In addition to attending to the health of the employees, it is of course necessary to provide for policing the Zone. This is done by a police force which at present numbers over 200 men, under Captain Shanton. About one-fifth of the men are white and the others black. In different places I questioned some twenty or thirty of these men, taking them at random. They were a fine set, physically and in discipline. With one exception all the white men I questioned had served in the American Army, usually in the Philippines, and belonged to the best type of American soldier. Without exception the black policemen whom I questioned had served either in the British army or in the Jamaica or Barbados police. They were evidently contented, and were doing their work well. Where possible the policemen are used to control people of their own color, but in any emergency no hesitation is felt in using them indiscriminately.

Inasmuch as so many both of the white and colored

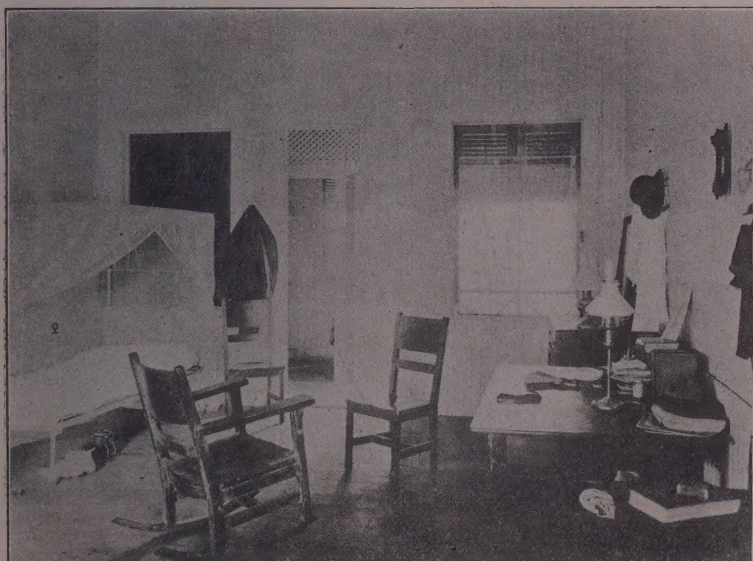
in their homes; and I conversed with probably a couple of hundred of them all told, choosing them at random from every class and including those who came especially to present certain grievances. I found that those who did not come specifically to present grievances almost invariably express far greater content and satisfaction with the conditions than did those who called to make complaint.

Nearly 5,000 of the white employees had come from the United States. No man can see these young, vigorous men energetically doing their duty without a thrill of pride in them as Americans. They represent on the average a high class. Doubtless to Congress the wages paid them will seem high, but as a matter of fact the only general complaint which I found had any real basis among the complaints made to me upon the Isthmus was that, owing to the peculiar surroundings, the cost of living, and the distance from home, the wages were really not as high as they should be. In fact, almost every man I spoke to felt that he ought to be receiving more money—a view, however, which the average man who stays at home in the United States probably likewise holds as regards himself. I append figures of the wages paid, so that the Congress can judge the matter for itself. Later I shall confer on the subject with certain representative labor men here in the United States, as well as going over with Mr. Stevens, the comparative wages paid on the Zone and at home; and I may then communicate my findings to the canal committees of the two Houses.

Quarters Good and Satisfactory.—The white Americans are employed, some of them in office work, but the majority in handling the great steam shovels, as engineers and conductors on the dirt trains, as machinists in the great repair shops, as carpenters and timekeepers, superintendents, and foremen of divisions and of gangs, and so on and so on. Many of them have brought down their wives and families; and the children when not in

that touch of attractiveness which, of course, the bachelor quarters neither had nor could have.

Food Supplies.—The housewives purchase their supplies directly, or thru their husbands, from the commissary stores of the Commission. All to whom I spoke agreed that the supplies were excellent, and all but two stated that there was no complaint to be made; these two complained that the prices were excessive as compared to the prices in the States. On investigation I did not feel that this complaint was well founded. The married men ate at home. The unmarried men sometimes ate at private boarding houses, or private messes, but more often, judging by the answers of those whom I questioned, at the government canteens or hotels, where the meal costs 30 cents to each employee. This 30-cent meal struck me as being as good a meal as we get in the United States at the ordinary hotel in which a 50-cent meal is provided. Three-fourths of the men whom I questioned stated that the meals furnished at these government hotels were good, the remaining one-fourth that they were not good. I myself took dinner at the La Boca government hotel, no warning whatever having been given of my coming. There were two rooms; as generally in these hotels. In one the employees were allowed to dine without their coats, while in the other they had to put them on. The 30-cent meal included soup, native beef (which was good), mashed potatoes, peas, beets, chili con carne, plum pudding, tea, coffee—each man having as much of each dish as he desired. On the table there was a bottle of liquid quinine tonic, which two-thirds of the guests, as I was informed, used every day. There were neat tablecloths and napkins. The men, who were taking the meal at or about the same time, included railroad men, machinists, shipwrights, and members of the office force. The rooms were clean, comfortable, and airy, with mosquito screens around the outer piazza. I was informed by some of those present that this hotel, and also the other similar hotels, were every Saturday night



Room in Bachelor Quarters, Culebra.



Dining Room, Married Quarters, Culebra.

employees have brought their families with them, schools have been established, the school service being under Mr. O'Connor. For the white pupils white American teachers are employed; for the colored pupils there are also some white American teachers, one Spanish teacher, and one colored American teacher, most of them being colored teachers from Jamaica, Barbados, and St. Lucia. The schoolrooms were good, and it was a pleasant thing to see the pride that the teachers were taking in their work and their pupils.

There seemed to me to be too many saloons in the Zone; but the new high-license law which goes into effect on January 1 next will probably close four-fifths of them. Resolute and successful efforts are being made to minimize and control the sale of liquor.

The cars on the passenger trains on the Isthmus are divided into first and second class, the difference being marked in the price of tickets. As a rule second-class passengers are colored and first-class passengers white; but in every train which I saw there were a number of white second-class passengers, and on two of them there were colored first-class passengers.

Care of Employees.—Next in importance to the problem of sanitation, and indeed now of equal importance, is the problem of securing and caring for the mechanics, laborers, and other employees who actually do the work on the canal and the railroad. This great task has been under the control of Mr. Jackson Smith, and on the whole has been well done. At present there are some 6,000 white employees and some 10,000 colored employees on the Isthmus. I went over the different places where the different kinds of employees were working; I think I saw representatives of every type both at their work and

school are running about and behaving precisely as the American small boy and small girl behave at home. The bachelors among the employees live, sometimes in small separate houses, sometimes in large houses; quarters being furnished free to all the men, married and unmarried. Usually the bachelors sleep two in a room, as they would do in this country. I found a few cases where three were in a room; and I was told of, altho I did not see, large rooms in which four were sleeping; for it is not possible in what is really a vast system of construction camps always to provide in advance as ample house room as the Commission intend later to give. In one case where the house was an old French house with a leak in the roof, I did not think the accommodations were good. But in every other case among the scores of houses I entered at random, the accommodations were good; every room was neat and clean, usually having books, magazines, and small ornaments; and in short just such a room as a self-respecting craftsman would be glad to live in at home. The quarters for the married people were even better. Doubtless there must be here and there a married couple who, with or without reason, are not contented with their house on the Isthmus; but I never happened to strike such a couple. The wives of the steam-shovel men, engineers, machinists, and carpenters into whose houses I went, all with one accord express their pleasure in their home life and surroundings. Indeed I do not think they could have done otherwise. The houses themselves were excellent—bathroom, sitting room, piazza, and bedrooms being all that could be desired. In every house which I happened to enter the mistress of the home was evidently a good American housewife and helpmeet, who had given to the home life

turned into clubhouses where the American officials, the school teachers, and various employees, appeared, bringing their wives, there being dancing and singing. There was a piano in the room, which I was informed was used for the music on these occasions. My meal was excellent, and two newspaper correspondents who had been on the Isthmus several days informed me that it was precisely like the meals they had been getting elsewhere at other Government hotels. One of the employees was a cousin of one of the Secret-Service men who was with me, and he stated that the meals had always been good, but that after a time he grew tired of them because they seemed so much alike.

No Cause for Complaint About Food.—I came to the conclusion that, speaking generally, there was no warrant for complaint about the food. Doubtless it grows monotonous after awhile. Any man accustomed to handling large masses of men knows that some of them, even tho otherwise very good men, are sure to grumble about something, and usually about their food. Schoolboys, college boys, and boarders in boarding houses make similar complaints; so do soldiers and sailors. On this very trip, on one of the warships, a seaman came to complain to the second watch officer about the quality of the cocoa at the seamen's mess, saying that it was not sweet enough; it was pointed out to him that there was sugar on the table and he could always put it in, to which he responded that that was the cook's business and not his! I think that the complaint as to the food on the Isthmus has but little more foundation than that of the sailor in question. Moreover, I was given to understand that one real cause of complaint was that at the government hotels no liquor is served, and some of

the drinking men, therefore, refused to go to them. The number of men using the Government hotels is steadily increasing.

Chinese and Other Labor.—Of the nineteen or twenty thousand day laborers employed on the canal, a few hundred are Spaniards. These do excellent work. Their foremen told me that they did twice as well as the West India laborers. They keep healthy and no difficulty is experienced with them in any way. Some Italian laborers are also employed in connection with the drilling. As might be expected, with labor as high priced as at present in the United States, it has not so far proved practicable to get any ordinary laborers from the United States. The American wage-workers on the Isthmus are the highly paid skilled mechanics of the types mentioned previously. A steady effort is being made to secure Italians, and especially to procure more Spaniards, because of the very satisfactory results that have come from their employment; and their numbers will be increased as far as possible. It has not proved possible, however, to get them in anything like the numbers needed for the work, and from present appearances we shall in the main have to rely, for the ordinary unskilled work, partly upon colored laborers from the West Indies; partly upon Chinese labor. It certainly ought to be unnecessary to point out that the American workingman in the United States has no concern whatever in the question as to whether the rough work on the Isthmus, which is performed by aliens in any event, is done by aliens from one country with a black skin or by aliens from another country with a yellow skin. Our business is to

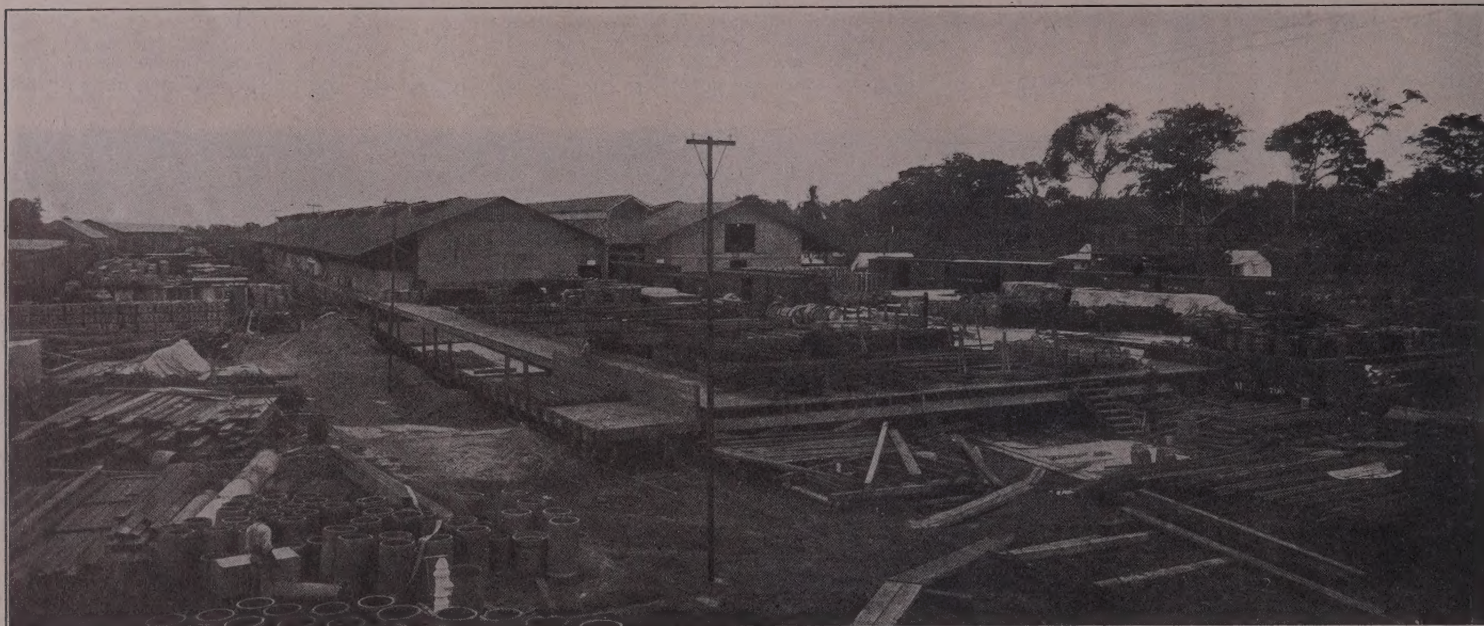
visual was himself a West India man of color, either a policeman, a storekeeper, or an assistant storekeeper. Doubtless there must be many complaints against Americans; but those to whom I spoke did not happen to make any such complaint to me. There was no complaint of the housing; I saw but one set of quarters for colored laborers which I thought poor, and this was in an old French house. The barracks for unmarried men are roomy, well ventilated, and clean, with canvas bunks for each man, and a kind of false attic at the top, where the trunks and other belongings of the different men are kept. The clothes are hung on clotheslines, nothing being allowed to be kept on the floor. In each of these big rooms there were tables and lamps, and usually a few books or papers, and in almost every room there was a Bible; the books being the property of the laborers themselves. The cleanliness of the quarters is secured by daily inspection. The quarters for the married negro laborers were good. They were neatly kept, and in almost every case the men living in them, whose wives or daughters did the cooking for them, were far better satisfied and of a higher grade than the ordinary bachelor negroes. Not only were the quarters in which these negro laborers were living much superior to those in which I am informed they live at home, but they were much superior to the huts to be seen in the jungles of Panama itself, beside the railroad tracks, in which the lower class of native Panamanians live, as well as the negro workmen when they leave the employ of the canal and go into the jungles. A single glance at the two sets of buildings is enough to show the great superiority in

an effort should be made to secure them a more ample supply of their favorite food, and so directed; and I believe that ultimately the Government must itself feed them. I am having this matter looked into.

The superintendent having immediate charge of one gang of men at the Colon reservoir stated that he endeavored to get them to substitute beans and other nourishing food for the stringy, watery yams, because the men keep their strength and health better on the more nourishing food. Inasmuch, however, as they are accustomed to yams it is difficult to get them to eat the more strengthening food, and some time elapses before they grow accustomed to it. At this reservoir there has been a curious experience. It is off in the jungle by itself at the end of a couple of miles of a little toy railroad. In order to get the laborers there, they were given free food (and of course free lodgings); and yet it proved difficult to keep them, because they wished to be where they could reach the dramshop and places of amusement.

I was struck by the superior comfort and respectability of the lives of the married men. It would, in my opinion, be a most admirable thing if a much larger number of the men had their wives, for with their advent all complaints about the food and cooking are almost sure to cease.

I had an interview with Mr. Mallet, the British consul, to find out if there was any just cause for complaint as to the treatment of the West India negroes. He informed me most emphatically that there was not, and authorized me to give his statement publicity. He said that not only was the condition of the laborers far better



The Mount Hope Store of the Isthmian Canal Commission, through which all Supplies are Distributed.

dig the canal as efficiently and as quickly as possible; provided always that nothing is done that is inhumane to any laborers, and nothing that interferes with the wages of or lowers the standard of living of our own workmen. Having in view this principle, I have arranged to try several thousand Chinese laborers. This is desirable both because we must try to find out what laborers are most efficient, and, furthermore, because we should not leave ourselves at the mercy of any one type of foreign labor. At present the great bulk of the unskilled labor on the Isthmus is done by West India negroes, chiefly from Jamaica, Barbados, and the other English possessions. One of the governors of the lands in question has shown an unfriendly disposition to our work, and has thrown obstacles in the way of our getting the labor needed; and it is highly undesirable to give any outsiders the impression, however ill founded, that they are indispensable and can dictate terms to us.

Negro Laborers and Their Quarter.—The West India laborers are fairly, but only fairly, satisfactory. Some of the men do very well indeed; the better class, who are to be found as foremen, as skilled mechanics, as policemen, are good men; and many of the ordinary day laborers are also good. But thousands of those who are brought over under contract (at our expense) go off into the jungle to live, or loaf around Colon, or work so badly after the first three or four days as to cause a serious diminution of the amount of labor performed on Friday and Saturday of each week. I questioned many of these Jamaica laborers as to the conditions of their work and what, if any changes, they wished. I received many complaints from them, but as regards most of these complaints they themselves contradicted one another. In all cases where the complaint was as to their treatment by any individual it proved on examination that this indi-

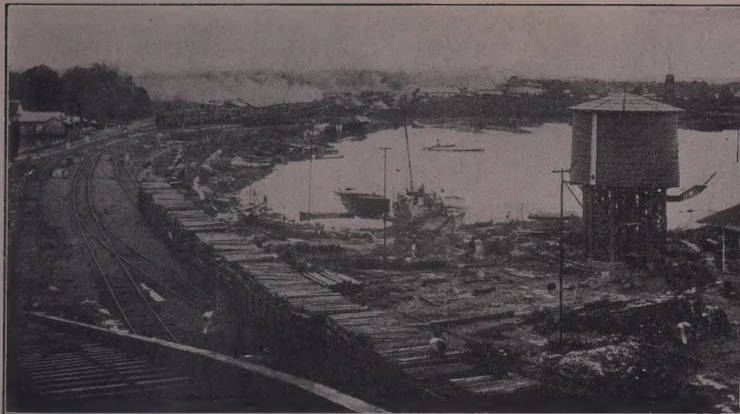
point of comfort, cleanliness, and healthfulness of the Government houses as compared with the native houses.

Negroes Do Their Own Cooking.—The negroes generally do their own cooking, the bachelors cooking in sheds provided by the Government and using their own pots. In the different camps there was a wide variation in the character of these cooking sheds. In some, where the camps were completed, the kitchen or cooking sheds, as well as the bathrooms and water-closets, were all in excellent trim, while there were board sidewalks leading from building to building. In other camps the kitchens or cook sheds had not been floored, and the sidewalks had not been put down, while in one camp the bath houses were not yet up. In each case, however, every effort was being made to hurry on the construction, and I do not believe that the delays had been greater than were inevitable in such work. The laborers are accustomed to do their own cooking; but there was much complaint, especially among the bachelors, as to the quantity, and some, as to the quality, of the food they got from the commissary department, especially as regards yams. On the other hand, the married men and their wives, and the more advanced among the bachelors, almost invariably expressed themselves as entirely satisfied with their treatment at the commissary stores; except that they stated that they generally could not get yams there, and had to purchase them outside. The chief complaint was that the prices were too high. It is unavoidable that the prices should be higher than in their own homes; and after careful investigation I came to the conclusion that the chief trouble lay in the fact that the yams, plantains, and the like are rather perishable food, and are very bulky compared to the amount of nourishment they contain, so that it is costly to import them in large quantities and difficult to keep them. Nevertheless, I felt that

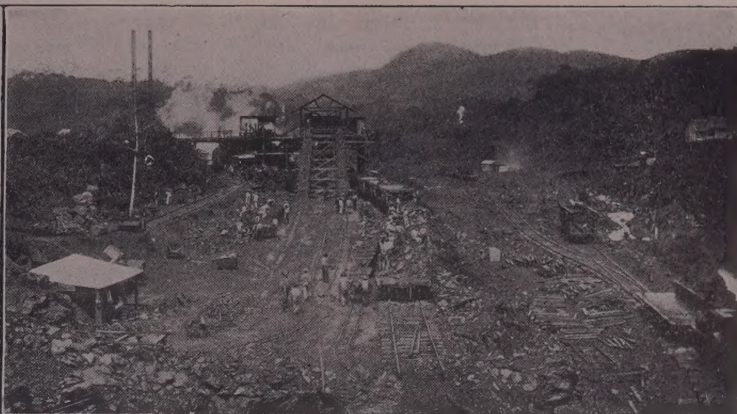
than had been the case under the old French Company, but that year by year the condition was improving under our own régime. He stated that complaints were continually brought to him, and that he always investigated them; and that for the last six months he had failed to find a single complaint of a serious nature that contained any justification whatever.

Recreation and Amusement.—One of the greatest needs at present is to provide amusements both for the white men and the black. The Young Men's Christian Association is trying to do good work and should be in every way encouraged. But the Government should do the main work. I have specifically called the attention of the Commission to this matter, and something has been accomplished already. Anything done for the welfare of the men adds to their efficiency, and money devoted to that purpose is therefore properly to be considered as spent in building the canal. It is imperatively necessary to provide ample recreation and amusement if the men are to be kept well and healthy. I call the special attention of Congress to this need.

This gathering, distributing, and caring for the great force of laborers is one of the giant features of the work. That friction will from time to time occur in connection therewith is inevitable. The astonishing thing is that the work has been performed so well and that the machinery runs so smoothly. From my own experience I am able to say that more care had been exercised in housing, feeding, and generally paying heed to the needs of the skilled mechanics and ordinary laborers in the work on this canal than is the case in the construction of new railroads or in any other similar private or public work in the United States proper; and it is the testimony of all people competent to speak that on no other similar work anywhere in the Tropics—indeed, as far as I know,



Railway Yard at Cristobal.



Stone Cutter at Bas Obispo.

anywhere else—has there been such forethought and such success achieved in providing for the needs of the men who do the work.

I have now dealt with the hygienic conditions which make it possible to employ a great force of laborers, and with the task of gathering, housing, and feeding these laborers. There remains to consider the actual work which has to be done; the work because of which these laborers are gathered together—the work of constructing the canal. This is under the direct control of the Chief Engineer, Mr. Stevens, who has already shown admirable results, and whom we can safely trust to achieve similar results in the future.

Our people found on the Isthmus a certain amount of old French material and equipment which could be used. Some of it, in addition, could be sold as scrap iron. Some could be used for furnishing the foundation for filling in. For much no possible use could be devised that would not cost more than it would bring in.

Work of Construction.—The work is now going on with a vigor and efficiency pleasant to witness. The three big problems of the canal are the La Boca dams, the Gatun dam, and the Culebra cut. The Culebra cut must be made, anyhow; but of course changes as to the dams, or at least as to the locks adjacent to the dams, may still occur. The La Boca dams offer no particular problem, the bottom material being so good that there is a practical certainty, not merely as to what can be achieved, but as to the time of achievement. The Gatun dam offers the most serious problem which we have to solve; and yet the ablest men on the Isthmus believe that this problem is certain of solution along the lines proposed; altho, of course, it necessitates great toil, energy, and intelligence, and altho equally, of course, there will be some little risk in connection with the work. If the huge earth dam now contemplated is thrown across from one foothill to the other we will have what is practically a low, broad, mountain ridge behind which will rise the inland lake. This artificial mountain will probably show less seepage, that is, will have greater restraining capacity, than the average natural mountain range. The exact locality of the locks at this dam—as at the other dams—is now being determined. In April next Secretary Taft, with three of the ablest engineers of the country—Messrs. Noble, Stearns, and Ripley—will visit the Isthmus, and the three engineers will make the final and conclusive examinations as to the exact site for each lock. Meanwhile the work is going ahead without a break.

The Culebra cut does not offer such great risks; that is, the damage liable to occur from occasional landslips will not represent what may be called major disasters. The work will merely call for intelligence, perseverance,

and executive capacity. It is, however, the work upon which most labor will have to be spent. The dams will be composed of the earth taken out of the cut, and very possibly the building of the locks and dams will take even longer than the cutting in Culebra itself.

In Culebra Cut.—The main work is now being done in the Culebra cut. It was striking and impressive to see the huge steam shovels in full play, the dumping trains carrying away the rock and earth they dislodged. The implements of French excavating machinery, which often stand a little way from the line of work, tho of excellent construction, look like the veriest toys when compared with these new steam shovels, just as the French dumping cars seem like toy cars when compared with the long trains of huge cars, dumped by steam plows, which are now in use. This represents the enormous advance that has been made in machinery during the past quarter of a century. No doubt a quarter of a century hence this new machinery, of which we are now so proud, will similarly seem out of date, but it is certainly serving its purpose well now. The old French cars had to be entirely discarded. We still have in use a few of the more modern, but not most modern, cars, which hold but 12 yards of earth. They can be employed on certain lines with sharp curves. But the recent cars hold from 25 to 30 yards apiece, and instead of the old clumsy methods of unloading them, a steam plow is drawn from end to end of the whole vested train, thus immensely economizing labor. In the rainy season the steam shovels can do but little in dirt, but they work steadily in rock and in the harder ground. There were some 25 at work during the time I was on the Isthmus, and their tremendous power and efficiency were most impressive.

New Records for Excavation.—As soon as the type of canal was decided this work began in good earnest. The rainy season will shortly be over and then there will be an immense increase in the amount taken out; but even during the last three months, in the rainy season, steady progress is shown by the figures: In August, 242,000 cu. yd.; in September, 291,000 cu. yd., and in October, 325,000 cu. yd. In October new records were established for the output of individual shovels as well as for the tonnage haul of individual locomotives. I hope to see the growth of a healthy spirit of emulation between the different shovel and locomotive crews, just such a spirit as has grown on our battleships between the different gun crews in matters of marksmanship. Passing thru the cut the amount of new work can be seen at a glance. In one place the entire side of a hill had been taken out recently by 27 tons of dynamite, which were exploded at one blast. At another place I was given a Presidential salute of 21 charges of dynamite. On the

top notch of the Culebra cut the prism is now as wide as it will be; all told, the canal bed at this point has now been sunk about 200 ft. below what it originally was. It will have to be sunk about 130 ft. farther. Thruout the cut the drilling, blasting, shoveling, and hauling are going on with constantly increasing energy, the huge shovels being prest up, as if they were mountain howitzers, into the most unlikely looking places, where they eat their way into the hillsides.

Railway Improvements.—The most advanced methods, not only in construction, but in railroad management, have been applied in the Zone, with corresponding economies in time and cost. This has been shown in the handling of the tonnage from ships into cars, and from cars into ships, on the Panama Railroad, where, thanks largely to the efficiency of General Manager Bierd, the saving in time and cost has been noteworthy. My examination tended to show that some of the departments had (doubtless necessarily) become overdeveloped, and could now be reduced or subordinated without impairment of efficiency and with a saving of cost. The Chairman of the Commission, Mr. Shonts, has all matters of this kind constantly in view, and is now reorganizing the government of the Zone, so as to make the form of administration both more flexible and less expensive, subordinating everything to direct efficiency with a view of the work of the Canal Commission. From time to time changes of this kind will undoubtedly have to be made, for it must be remembered that in this giant work of construction, it is continually necessary to develop departments or bureaus, which are vital for the time being, but which soon become useless; just as it will be continually necessary to put up buildings, and even to erect towns, which in ten years will once more give place to jungle, or will then be at the bottom of the great lakes at the ends of the canal.

Critics and Doubting Thomases.—It is not only natural, but inevitable, that a work as gigantic as this which has been undertaken on the Isthmus should arouse every species of hostility and criticism. The conditions are so new and so trying, and the work so vast, that it would be absolutely out of the question that mistakes should not be made. Checks will occur. Unforeseen difficulties will arise. From time to time seemingly well-settled plans will have to be changed. At present 25,000 men are engaged on the task. After a while the number will be doubled, here and there a scoundrel. Very many of the poorer class of laborers lack the mental development to protect themselves against either the rascality of others or their own folly, and it is not possible for human wisdom to devise a plan by which they can invariably be protected. In a place which has been for ages a byword for unhealthfulness, and with so large a congregation of strang-



Receiving Hospital at Empire.



Negro Quarters at Rio Grande

ers suddenly put down and set to hard work, there will now and then be outbreaks of disease. There will now and then be shortcomings in administration; there will be unlooked-for accidents to delay the excavation of the cut or the building of the dams and locks. Each such incident will be entirely natural, and, even tho serious, no one of them will mean more than a little extra delay or trouble. Yet each, when discovered by sensation mongers and retailed to timid folk of little faith, will serve as an excuse for the belief that the whole work is being badly managed. Experiments will continually be tried in housing, in hygiene, in street repairing, in dredging, and in digging earth and rock. Now and then an experiment will be a failure; and among those who hear of it, a certain proportion of doubting Thomases will at once believe that the whole work is a failure. Doubtless here and

worth while for responsible contractors of the best kind to undertake the work; and provided on the other hand it can be done on terms which will not give an excessive profit to the contractor at the expense of the Government. After much consideration the plan already promulgated by the Secretary of War was adopted. This plan in its essential features was drafted, after careful and thoro study and consideration, by the Chief Engineer, Mr. Stevens, who, while in the employment of Mr. Hill, the president of the Great Northern R. R., had personal experience of this very type of contract. Mr. Stevens then submitted the plan to the chairman of the Commission, Mr. Shonts, who went carefully over it with Mr. Rogers, the legal adviser of the Commission, to see that all legal difficulties were met. He then submitted copies of the plan to both Secretary Taft and myself. Secretary

should have but one commissioner, with such heads of departments and other officers under him as we may find necessary. We should be expressly permitted to employ the best engineers in the country as consulting engineers.

I accompany this paper with a map showing substantially what the canal will be like when it is finished. When the Culebra cut has been made and the dams built (if they are built as at present proposed) there will then be at both the Pacific and Atlantic ends of the canal, two great fresh-water lakes, connected by a broad channel running at the bottom of a ravine, across the backbone of the Western Hemisphere. Those best informed believe that the work will be completed in about eight years; but it is never safe to prophesy about such a work as this, especially in the Tropics.

I am informed that representatives of the commercial clubs of four cities—Boston, Chicago, Cincinnati, and St. Louis—the membership of which includes most of the leading business men of those cities, expect to visit the Isthmus for the purpose of examining the work of construction of the canal. I am glad to hear it, and I shall direct that every facility be given them to see all that is to be seen in the work which the Government is doing. Such interest as a visit like this would indicate will have a good effect upon the men who are doing the work, on one hand, while on the other hand it will offer as witnesses of the exact conditions men whose experience as business men and whose impartiality will make the result of their observations of value to the country as a whole.

Confident of Ultimate Success.—Of the success of the enterprise I am as well convinced as one can be of any enterprise that is human. It is a stupendous work upon which our fellow-countrymen are engaged down there on the Isthmus, and while we should hold them to a strict accountability for the way in which they perform it, we should yet recognize, with frank generosity, the epic nature of the task on which they are engaged and its world-wide importance. They are doing something which will redound immeasurably to the credit of America, which will benefit all the world, and which will last for ages to come. Under Mr. Shonts and Mr. Stevens and Dr. Gorgas this work has started with every omen of good for-



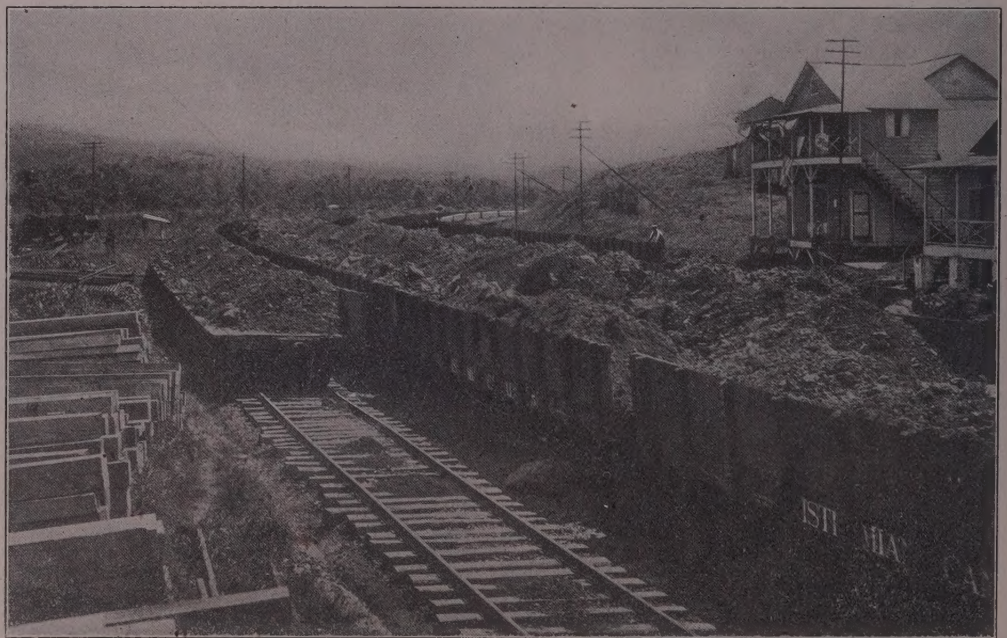
View in the Culebra Cut.

there some minor rascality will be uncovered; but as to this, I have to say that after the most painstaking inquiry I have been unable to find a single reputable person who had so much as heard of any serious accusations affecting the honesty of the Commission or of any responsible officer under it. I append a letter dealing with the most serious charge, that of the ownership of lots in Colon; the charge was not advanced by a reputable man, and is utterly baseless. It is not too much to say that the whole atmosphere of the Commission breathes honesty as it breathes efficiency and energy. Above all, the work has been kept absolutely clear of politics. I have never heard even a suggestion of spoils politics in connection with it.

I have investigated every complaint brought to me for which there seemed to be any shadow of foundation. In two or three cases, all of which I have indicated in the course of this message, I came to the conclusion that there was foundation for the complaint, and that the methods of the Commission in the respect complained of could be bettered. In the other instances the complaints proved absolutely baseless, save in two or three instances where they referred to mistakes which the Commission had already itself found out and corrected.

Slanderers and Libelers.—So much for honest criticism. There remains an immense amount of as reckless slander as has ever been published. Where the slanderers are of foreign origin I have no concern with them. Where they are Americans, I feel for them the heartiest contempt and indignation; because, in a spirit of wanton dishonesty and malice, they are trying to interfere with, and hamper the execution of, the greatest work of the kind ever attempted, and are seeking to bring to naught the efforts of their countrymen to put to the credit of America one of the giant feats of the ages. The outrageous accusations of these slanderers constitute a gross libel upon a body of public servants who, for trained intelligence, expert ability, high character and devotion to duty, have never been excelled anywhere. There is not a man among those directing the work on the Isthmus who has obtained his position on any other basis than merit alone, and not one who has used his position in any way for his own personal or pecuniary advantage.

Plan to Build by Contract.—After most careful consideration we have decided to let out most of the work by contract, if we can come to satisfactory terms with the contractors. The whole work is of a kind suited to the peculiar genius of our people; and our people have developed the type of contractor best fitted to grapple with it. It is of course much better to do the work in large part by contract than to do it all by the Government, provided it is possible on the one hand to secure to the contractor a sufficient remuneration to make



Part of Las Cascadas Yard for Spoil Cars from the Culebra Cut.

Taft submitted it to some of the best counsel at the New York bar, and afterwards I went over it very carefully with Mr. Taft and Mr. Shonts, and we laid the plan in its general features before Mr. Root. My conclusion is that it combines the maximum of advantage with the minimum of disadvantage. Under it a premium will be put upon the speedy and economical construction of the canal, and a penalty imposed on delay and waste. The plan as promulgated is tentative; doubtless it will have to be changed in some respects before we can come to a satisfactory agreement with responsible contractors—perhaps even after the bids have been received; and of course it is impossible that we can not come to an agreement, in which case the Government will do the work itself. Meanwhile the work on the Isthmus is progressing steadily and without any let-up.

A Single Commissioner Desired.—A seven-headed committee mission is of course a clumsy executive instrument. We

tune. They and their worthy associates, from the highest to the lowest, are entitled to the same credit that we would give to the picked men of a victorious army; for this conquest of peace will, in its great and far-reaching effect, stand as among the very greatest conquests, whether of peace or of war, which have ever been won by any of the peoples of mankind. A badge is to be given to every American citizen who for a specified time has taken part in this work; for participation in it will hereafter be held to reflect honor upon the man participating just as it reflects honor upon a soldier to have belonged to a mighty army in a great war for righteousness. Our fellow-countrymen on the Isthmus are working for our interest and for the national renown in the same spirit and with the same efficiency that the men of the Army and Navy work in time of war. It behooves us in our turn to do all we can to hold up their hands and to aid them in every way to bring their great work to a triumphant conclusion.